BACKGROUND DOCUMENTATION FOR THE DEVELOPMENT OF THE MCP NUMERICAL STANDARDS

DEP

Massachusetts Department of
Environmental Protection
Bureau of Waste Site Cleanup
and
Office of Research and Standards

April, 1994

Published by the Office of the Secretary of State,
Michael Joseph Connolly, Secretary

$13.15

TABLE OF CONTENTS

TABLES

FIGURES

Appendices

1.0 INTRODUCTION

The development of chemical-specific cleanup standards for use under the revised Massachusetts Contingency Plan represents an important piece of the effort to streamline the site assessment and remediation program. The MCP Numerical Standards provide a simple means to determine whether remediation is necessary at a site and when no further remedial response action is necessary. This document describes the factors which have been considered in the generation of these standards.

The development of the MCP Method 1 Standards is best considered within the framework of the regulations which allow flexibility in the characterization of the risk of harm to health, safety, public welfare and the environment. The regulations retain site-specific risk assessment as an optional means (Method 3) to establish the need for remediation and to determine cleanup goals. The time and cost of preparing such assessments may not be warranted at many of the M.G.L. c.21E sites, however. Promulgated standards provide an option which is simple to use and results in predictable outcomes. The Department is also offering a hybrid methodology (Method 2) which allows limited modification of the Method 1 Standards based upon site-specific information. All three Methods address the potential risk of harm to health, public welfare and the environment. Risk to safety is considered separately.

In addition to the main body of this document which describes the derivation of the Method 1 Standards, there are a number of appendices which examine related issues. Appendices A, B, and C explain the derivation of the Method 1 Soil 1, 2, and 3 (S-1, S-2, and S-3) ingestion and skin contact rates. Appendix D describes soil levels which trigger an imminent hazard evaluation under the MCP. An explanation of the Reportable Concentrations contained in the MCP is given in Appendix E. The dilution/attenuation factors (DAFs) used to develop the leaching-based Method 1 soil standards are explained in Appendix F. Finally, Appendix G examines the selection of Practical Quantitation Limits (PQLs) for Method 1 chemicals.

1.1. GOALS

The MCP Method 1 Standards are intended to represent levels of oil or hazardous materials at which no further remedial response actions would be required based upon the risk of harm posed by these chemicals. The standards must be protective of public health, public welfare, and the environment (i.e., represent a condition of "no significant risk"), given the exposures assumed, and must be measurable.

Method 1 standards are, by nature, generic, and are derived in a manner to be protective at a wide range of disposal sites across the state. The use of such generic standards is one risk characterization option in the Massachusetts Contingency Plan. It is important to remember that the flexibility exists under the MCP to use more site-specific risk characterization approaches under Methods 2 and 3.

1.2. CATEGORIES OF STANDARDS

This document describes the development of standards in soil and in groundwater based upon assumptions made for the current and foreseeable uses of the site and surrounding environment.

These use categories are described in the regulations by specific criteria to determine the applicable categories.

The groundwater standards described in section 4 of this document include:

Category GW-1:	Concentrations based upon the use of the groundwater as drinking water, either currently or in the foreseeable future.
Category GW-2:	Concentrations based upon the potential for volatile materials to migrate into indoor air.
Category GW-3:	Concentrations based upon potential environmental impacts of contaminated groundwater discharging to surface water.
Upper Concentration Limits:	Concentrations promulgated for the protection of groundwater as a future resource and considering the social costs of degraded aquifers.

The soil standards described in section 5 of this document include:

Category S-1:	Concentrations based upon sensitive uses of the property and accessible soil, either currently or in the foreseeable future. Additional criteria are established for the protection of groundwater, based upon leaching from the soils.
Category S-2:	Concentrations based upon property uses associated with moderate exposure and accessible soils, either currently or in the foreseeable future. Additional criteria are established for the protection of groundwater, based upon leaching from the soils.
Category S-3:	Concentrations based upon restricted access property with limited potential for exposure, either currently or in the foreseeable future. Additional criteria are established for the protection of groundwater, based upon leaching from the soils.
Upper Concentration Limits:	Concentrations promulgated to minimize potential risks associated with uncontrolled environmental contamination, and the costs associated with cumulative anthropogenic contributions to background.

Figure 1-1, extracted from the regulations, provides an outline of the applicability of the soil standards. Figure 1-2 provides an example of how to use the tables of standards once the applicable soil and groundwater categories have been determined.

FIGURE 1-1

SOIL CATEGORY SELECTION MATRIX - HUMAN EXPOSURE POTENTIAL

	RECEPTOR CHARACTERISTICS							
	CHILDREN PRESENT				ADULTS PRESENT			
	HIGH FREQUENCY		LOW FREQUENCY		HIGH FREQUENCY		LOW FREQUENCY	
Accessibility ↓ of Soil ↓	High Intensity	Low Intensity	High Intensity	Low Intensity	High Intensity	Low Intensity	High Intensity	Low Intensity
ACCESSIBLE (SURFICIAL) SOIL 0 -> 3′ (unpaved)		CATEGORY S-1		S-2	S-1	CATEGORY S-2		
POTENTIALLY ACCESSIBLE SOIL 0 -> 15′ (paved) - or - 3 -> 15′ (unpaved)		CATEGORY S-2			S-2		CATEGORY S-3	
ISOLATED SUB-SURFACE SOILS > 15′ or under the footprint of a building or permanent structure		CATEGORY S-3						

FIGURE 1-2

A SIMPLE GUIDE TO METHOD 1 STANDARDS

EXAMPLE: *Based on the criteria in the MCP, the groundwater at the disposal site is determined to be Category GW-3 only, and the soil of concern is categorized as S-2. The applicable standards (shaded below) under MCP Method 1 would be the GW-3 concentrations in groundwater (µg/liter, or ppb) and the S-2/GW-3 concentrations in soil (µg/gram, or ppm). In the MCP these standards are located on Tables 1 and 3, respectively.*

If the Groundwater Category is:	GW-1	GW-2	GW-3

Table 1: 40.0974(2)

Then these Groundwater Standards apply AND the Soil Standards directly below them are potentially applicable: ->	GW-1 µg/liter	GW-2 µg/liter	GW-3 µg/liter

If the Soil Category is: ↓↓

Then these Soil Standards are applicable, depending upon the Groundwater Category:

Table 2; 40.0975(6)(a)

S-1	S-1/GW-1 µg/gram	S-1/GW-2 µg/gram	S-1/GW-3 µg/gram

Table 3: 40.0975(6)(b)

S-2	S-2/GW-1 µg/gram	S-2/GW-2 µg/gram	S-2/GW-3 µg/gram

Table 4: 40.0975(6)(c)

S-3	S-3/GW-1 µg/gram	S-3/GW-2 µg/gram	S-3/GW-3 µg/gram

The specific assumptions which determine the concentration of oil or hazardous materials for each of these categories are described in the remainder of this document.

Each category is intended to represent a wide range of sites, and the risk assessment which is the basis for the numerical standard should not be expected to exactly describe each site determined to be in that category. In other words, even though the Soil S-1 concentrations are based upon a residential exposure scenario, the Department intends the S-1 standards to be potentially applicable at all locations where children have frequent or intense contact with the soil, *or may have such contact in the foreseeable future*. Thus S-1 standards may be called for in areas where the soil is not currently accessible, but where it is considered to be *potentially accessible*.

The exposure assumptions for each category have intentionally not been chosen to describe the "*worst-case*" exposure for that scenario. They are meant to be representative of the class of exposures expected for that category.

1.3 CHEMICALS FOR WHICH THERE ARE NO STANDARDS

Standards have been developed for one hundred and four chemicals or groups of chemicals most commonly reported at c.21E sites. If oil or hazardous material is confirmed to be present in soil or groundwater at a site, but there is not a promulgated Method 1 Standard for that chemical, then a standard may be developed using procedures outlined in the regulations (310 CMR 40.0983 and 40.0984). The development and use of such a standard is considered to be a Method 2 approach.

1.4 ENVIRONMENTAL MEDIA FOR WHICH THERE ARE NO STANDARDS

Standards have been developed for those environmental media which are most commonly found to be contaminated at c.21E sites: soil and groundwater. If oil or hazardous material is either confirmed or suspected to be in other media (i.e., surface water, air, sediments), then the Department considers the site to be sufficiently complex for a more detailed (Method 3) approach to risk characterization.

TABLE 1.1 CONTAINS THE MCP NUMERICAL STANDARDS

Groundwater Standards are found in Table 1 (310 CMR 40.0974(2)) of the MCP.

Soil Standards are found in Tables 2, 3 and 4 (310 CMR 40.0975(6)(a), (b), (c)) of the MCP.

Direct Contact Soil Standards are found in Table 5 (310 CMR 40.0985(6)) of the MCP.

Upper Concentration Limits in Groundwater and Soil are found in Table 6 (310 CMR 40.0996(4)) of the MCP.

TABLE 1.1

MCP NUMERICAL STANDARDS

TABLE 1-1 MCP NUMERICAL STANDARDS OIL AND/OR HAZARDOUS MATERIAL	Method 1 Groundwater Standards 310 CMR 40.0974(2) GW-1 STANDARD ug/L	GW-2 STANDARD ug/L	GW-3 STANDARD ug/L	Method 1 S-1 Soil Standards 310 CMR 40.0975(6)(a) S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	Method 1 S-2 Soil Standards 310 CMR 40.0975(6)(b) S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW-3 mg/kg
ACENAPHTHENE	20		2000	20	1000	1000	20	2500	200
ACENAPHTHYLENE	300		2000	100	100	100	100	2500	800
ACETONE	3000	50000	50000	3	60	60	3	60	60
ALDRIN	0.5	0.5	9	0.03	0.03	0.03	0.04	0.04	0.04
ANTHRACENE	600		600	1000	1000	1000	1000	2500	1000
ANTIMONY	6		300	10	10	10	40	40	40
ARSENIC	50		400	30	30	30	30	30	30
BENZENE	5	2000	7000	10	30	30	10	60	60
BENZO(a)ANTHRACENE	0.2		5	0.7	0.7	0.7	0.7	0.7	0.7
BENZO(a)PYRENE	0.2		2	0.7	0.7	0.7	0.7	0.7	0.7
BENZO(b)FLUORANTHENE	0.2		7	0.7	0.7	0.7	0.7	0.7	0.7
BENZO(g,h,i)PERYLENE	0.5		0.1	100	1000	30	100	2500	30
BENZO(k)FLUORANTHENE	0.2		0.4	0.7	0.7	0.7	0.7	0.7	0.7
BERYLLIUM	4		50	0.4	0.4	0.4	0.8	0.8	0.8
BIPHENYL, 1,1-	400		4000	1	1000	10	1	2500	10
BIS(2-CHLOROETHYL)ETHER	30	100	50000	0.7	0.7	0.7	0.7	0.7	0.7
BIS(2-CHLOROISOPROPYL)ETHER	30	400	50000	0.7	2	2	0.7	3	3
BIS(2-ETHYLHEXYL)PHTHALATE	6	700	30	100	100	100	100	300	300
BROMODICHLOROMETHANE	5		50000	0.1	10	10	0.1	20	20
BROMOFORM	5	800	50000	0.1	20	100	0.1	20	200
BROMOMETHANE	10	2	50000	10	3	50	10	3	200
CADMIUM	5		10	30	30	30	80	80	80
CARBON TETRACHLORIDE	5	20	50000	1	4	7	1	4	10
CHLORDANE	5		2	1	1	1	2	2	2
CHLOROANILINE, p-	30		50000	1	100	30	1	400	30
CHLOROBENZENE	100	1000	500	8	80	40	8	80	40
CHLOROFORM	5	400	10000	0.1	10	100	0.1	10	200
CHLOROPHENOL, 2-	10		40000	0.7	100	20	0.7	200	20
CHROMIUM (TOTAL)	100		2000	1000	1000	1000	2500	2500	2500
CHROMIUM (III)	100		2000	1000	1000	1000	2500	2500	2500
CHROMIUM (VI)	50		100	200	200	200	600	600	600
CHRYSENE	0.2		3	0.7	0.7	0.7	0.7	0.7	0.7
CYANIDE	200		10	100	100	100	100	100	100
DIBENZO(a,h)ANTHRACENE	0.2		0.3	0.7	0.7	0.7	0.7	0.7	0.7
DIBROMOCHLOROMETHANE	5		50000	0.09	10	10	0.09	20	20
DICHLOROBENZENE, 1,2- (o-DCB)	600	10000	8000	100	100	100	200	500	500
DICHLOROBENZENE, 1,3- (m-DCB)	600	10000	8000	100	100	100	200	500	500
DICHLOROBENZENE, 1,4- (p-DCB)	5	30000	8000	2	40	40	2	60	60
DICHLOROBENZIDINE, 3,3'-	80		2000	1	1	1	1	1	1
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)	0.1		6	2	2	2	3	3	3
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)	0.1		20	2	2	2	2	2	2
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)	0.3		0.3	2	2	2	2	2	2
DICHLOROETHANE, 1,1-	70	9000	50000	3	100	100	3	400	500
DICHLOROETHANE, 1,2-	5	20	50000	0.05	0.2	10	0.05	0.2	20
DICHLOROETHYLENE, 1,1-	7	1	50000	0.7	0.1	1	0.7	0.1	2
DICHLOROETHYLENE, CIS-1,2-	70		50000	2	100	100	2	500	500

-------------------- file: TXINF1-1.wk1, 4/20/94 --------------------

Table 1.1, continued...

TABLE 1-1

MCP NUMERICAL STANDARDS

OIL AND/OR HAZARDOUS MATERIAL	Method 1 Groundwater Standards 310 CMR 40.0974(2)			Method 1 S-1 Soil Standards 310 CMR 40.0975(6)(a)			Method 1 S-2 Soil Standards 310 CMR 40.0975(6)(b)		
	GW-1 STANDARD ug/L	GW-2 STANDARD ug/L	GW-3 STANDARD ug/L	S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW-3 mg/kg
DICHLOROETHYLENE, TRANS-1,2-	100		50000	4	500	500	4	1000	1000
DICHLOROPHENOL, 2,4-	10		4000	10	40	40	10	90	90
DICHLOROPROPANE, 1,2-	5	9	30000	0.1	0.2	8	0.1	0.2	10
DICHLOROPROPENE, 1,3-	0.5	5	2000	0.01	0.1	3	0.01	0.1	5
DIELDRIN	0.1		0.1	0.03	0.03	0.03	0.04	0.04	0.04
DIETHYL PHTHALATE	6000		30	100	1000	0.7	100	2500	0.7
DIMETHYL PHTHALATE	50000		30	30	1000	0.7	30	2500	0.7
DIMETHYLPHENOL, 2,4-	100		20000	0.7	400	10	0.7	900	10
DINITROPHENOL, 2,4-	200		2000	3	40	6	3	90	6
DINITROTOLUENE, 2,4-	30		2000	0.7	1	1	0.7	2	2
DIOXIN	3E-05		1E-04	4E-06	4E-06	4E-06	6E-06	6E-06	6E-06
ENDOSULFAN	0.4		0.1	0.2	1	0.05	0.2	3	0.05
ENDRIN	2		5	0.6	6	1	0.6	10	1
ETHYLBENZENE	700	30000	4000	80	500	500	80	1000	500
ETHYLENE DIBROMIDE	0.02	3	50000	0.005	0.01	0.01	0.005	0.02	0.02
FLUORANTHENE	100		100	600	900	600	600	2000	600
FLUORENE	300		1000	400	900	900	400	2000	1000
HEPTACHLOR	0.4		1	0.1	0.1	0.1	0.2	0.2	0.2
HEPTACHLOR EPOXIDE	0.2		2	0.06	0.06	0.06	0.09	0.09	0.09
HEXACHLOROBENZENE	1		40	0.7	0.7	0.7	0.8	0.8	0.8
HEXACHLOROBUTADIENE	0.6	1	90	3	3	7	3	3	10
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)	0.2		0.8	0.1	0.4	0.4	0.1	0.6	0.5
HEXACHLOROETHANE	8	10	5000	6	6	6	10	10	10
INDENO(1,2,3-cd)PYRENE	0.2		0.3	0.7	0.7	0.7	0.7	0.7	0.7
LEAD	15		30	300	300	300	600	600	600
MERCURY	2		1	10	10	10	60	60	60
METHOXYCHLOR	40		2	100	100	30	300	300	30
METHYL ETHYL KETONE	350	50000	50000	0.30	40	40	0.3	40	40
METHYL ISOBUTYL KETONE	350	50000	50000	0.5	70	70	0.5	70	70
METHYL MERCURY	2		0.1	7	7	7	20	20	20
METHYL TERT BUTYL ETHER	700	50000	50000	3	100	100	3	200	200
METHYLENE CHLORIDE	5	50000	50000	0.1	100	100	0.1	200	200
METHYLNAPHTHALENE, 2-	10	10000	3000	0.7	20	7	0.7	20	7
NAPHTHALENE	20	6000	6000	4	100	100	4	1000	1000
NICKEL	100		80	300	300	300	700	700	700
PENTACHLOROPHENOL	1		80	5	7	7	5	10	10
PHENANTHRENE	300		50	700	1000	100	700	2500	100
PHENOL	4000	50000	30000	60	500	500	60	800	500
POLYCHLORINATED BIPHENYLS	0.5		0.3	2	2	2	2	2	2
PYRENE	80		80	500	700	500	500	2000	500
SELENIUM	50		80	300	300	300	2500	2500	2500
SILVER	40		7	100	100	100	200	200	200
STYRENE	100	900	50000	2	20	20	2	20	30
TETRACHLOROETHANE, 1,1,1,2-	5	6	50000	0.4	0.5	4	0.4	0.5	5
TETRACHLOROETHANE, 1,1,2,2-	2	20	20000	0.02	0.2	0.5	0.02	0.2	0.6
TETRACHLOROETHYLENE	5	3000	5000	0.5	200	200	0.5	300	300

---------------------- file: TXINF1-1.wk1, 4/20/94 ----------------------

Table 1.1, continued...

TABLE 1-1 MCP NUMERICAL STANDARDS OIL AND/OR HAZARDOUS MATERIAL	Method 1 Groundwater Standards 310 CMR 40.0974(2) GW-1 STANDARD ug/L	GW-2 STANDARD ug/L	GW-3 STANDARD ug/L	Method 1 S-1 Soil Standards 310 CMR 40.0975(6)(a) S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	Method 1 S-2 Soil Standards 310 CMR 40.0975(6)(b) S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW-3 mg/kg
THALLIUM	2		400	8	8	8	30	30	30
TOLUENE	1000	6000	50000	90	500	500	90	500	1000
TOTAL PETROLEUM HYDROCARBONS	1000		50000	500	500	500	2500	2500	2500
TRICHLOROBENZENE, 1,2,4-	70	600	500	100	400	400	100	900	800
TRICHLOROETHANE, 1,1,1-	200	4000	50000	30	100	100	30	500	500
TRICHLOROETHANE, 1,1,2-	5	20000	50000	0.3	2	2	0.3	3	3
TRICHLOROETHYLENE	5	300	20000	0.4	20	70	0.4	20	100
TRICHLOROPHENOL, 2,4,5-	200		100	3	1000	2	3	2500	2
TRICHLOROPHENOL 2,4,6-	10	40000	10000	3	40	40	3	60	60
VINYL CHLORIDE	2	2	600	0.3	0.3	0.3	0.4	0.3	0.5
XYLENES	10000	6000	50000	500	500	500	800	500	1000
ZINC	2000		900	2500	2500	2500	2500	2500	2500

-------------------- file: TXINF1-1.wk1, 4/20/94 --------------------

Table 1.1, continued...

TABLE 1-1 MCP NUMERICAL STANDARDS	Method 1 S-3 Soil Standards 310 CMR 40.0975(6)(c)			Method 2 Direct Contact Soil Standards 310 CMR 40.0985(6)			Methods 2 & 3 Upper Concentration Limits (UCLs) 310 CMR 40.0996(4)	
OIL AND/OR HAZARDOUS MATERIAL	S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-3/GW-3 mg/kg	S-1 mg/kg	S-2 mg/kg	S-3 mg/kg	Groundwater ug/L	Soil ug/g
ACENAPHTHENE	20	5000	2000	1000	2500	5000	2000	10000
ACENAPHTHYLENE	100	2500	800	100	2500	2500	2000	10000
ACETONE	3	60	60	500	1000	2500	100000	10000
ALDRIN	0.1	0.1	0.1	0.03	0.04	0.1	9	1
ANTHRACENE	1000	5000	1000	1000	2500	5000	600	10000
ANTIMONY	40	40	40	10	40	40	3000	400
ARSENIC	30	30	30	30	30	30	4000	300
BENZENE	10	100	200	30	60	200	70000	2000
BENZO(a)ANTHRACENE	0.7	0.7	0.7	0.7	0.7	0.7	5	7
BENZO(a)PYRENE	0.7	0.7	0.7	0.7	0.7	0.7	2	7
BENZO(b)FLUORANTHENE	0.7	0.7	0.7	0.7	0.7	0.7	7	7
BENZO(g,h,i)PERYLENE	100	2500	30	1000	2500	2500	0.5	10000
BENZO(k)FLUORANTHENE	0.7	0.7	0.7	0.7	0.7	0.7	0.4	7
BERYLLIUM	3	3	3	0.4	0.8	3	500	30
BIPHENYL, 1,1-	1	3000	10	1000	2500	3000	4000	10000
BIS(2-CHLOROETHYL)ETHER	0.7	0.7	0.7	0.7	0.7	0.7	100000	7
BIS(2-CHLOROISOPROPYL)ETHER	0.7	4	9	2	3	9	100000	90
BIS(2-ETHYLHEXYL)PHTHALATE	100	1000	500	100	300	1000	700	10000
BROMODICHLOROMETHANE	0.1	90	90	10	20	90	100000	900
BROMOFORM	0.1	20	700	100	200	700	100000	7000
BROMOMETHANE	10	3	700	50	200	700	100000	7000
CADMIUM	80	80	80	30	80	80	100	800
CARBON TETRACHLORIDE	1	4	40	7	10	40	100000	400
CHLORDANE	5	5	5	1	2	5	50	50
CHLOROANILINE, p-	1	400	30	100	400	400	100000	4000
CHLOROBENZENE	8	80	40	500	1000	2500	10000	10000
CHLOROFORM	0.1	10	300	100	200	500	100000	5000
CHLOROPHENOL, 2-	0.7	1000	20	100	200	1000	100000	10000
CHROMIUM (TOTAL)	5000	5000	5000	1000	2500	5000	20000	10000
CHROMIUM (III)	5000	5000	5000	1000	2500	5000	20000	10000
CHROMIUM (VI)	1000	1000	1000	200	600	1000	1000	10000
CHRYSENE	0.7	0.7	0.7	0.7	0.7	0.7	3	7
CYANIDE	400	400	400	100	100	400	2000	4000
DIBENZO(a,h)ANTHRACENE	0.8	0.8	0.8	0.7	0.7	0.8	0.3	8
DIBROMOCHLOROMETHANE	0.09	70	70	10	20	70	100000	700
DICHLOROBENZENE, 1,2- (o-DCB)	200	500	500	100	500	500	100000	5000
DICHLOROBENZENE, 1,3- (m-DCB)	200	500	500	100	500	500	100000	5000
DICHLOROBENZENE, 1,4- (p-DCB)	2	200	200	40	60	200	40000	2000
DICHLOROBENZIDINE, 3,3'-	3	3	3	1	1	3	2000	30
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)	10	10	10	2	3	10	60	100
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)	9	9	9	2	2	9	20	90
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)	9	9	9	2	2	9	3	90
DICHLOROETHANE, 1,1-	3	400	500	100	500	500	100000	5000
DICHLOROETHANE, 1,2-	0.05	0.2	60	10	20	60	100000	600
DICHLOROETHYLENE, 1,1-	0.7	0.1	9	1	2	9	100000	90
DICHLOROETHYLENE, CIS-1,2-	2	500	500	100	500	500	100000	5000

-------------------- file: TXINF1-1.wk1, 4/20/94 --------------------

Table 1.1, continued...

TABLE 1-1

MCP NUMERICAL STANDARDS

OIL AND/OR HAZARDOUS MATERIAL	Method 1 S-3 Soil Standards 310 CMR 40.0975(6)(c)			Method 2 Direct Contact Soil Standards 310 CMR 40.0985(6)			Methods 2 & 3 Upper Concentration Limits (UCLs) 310 CMR 40.0996(4)	
	S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-3/GW-3 mg/kg	S-1 mg/kg	S-2 mg/kg	S-3 mg/kg	Groundwater ug/L	Soil ug/g
DICHLOROETHYLENE, TRANS-1,2-	4	2500	2000	500	1000	2500	100000	10000
DICHLOROPHENOL, 2,4-	10	90	90	40	90	90	40000	900
DICHLOROPROPANE, 1,2-	0.1	0.2	40	8	10	40	100000	400
DICHLOROPROPENE, 1,3-	0.01	0.1	20	3	5	20	20000	200
DIELDRIN	0.1	0.2	0.1	0.03	0.04	0.2	1	2
DIETHYL PHTHALATE	100	5000	0.7	1000	2500	5000	60000	10000
DIMETHYL PHTHALATE	30	5000	0.7	1000	2500	5000	100000	10000
DIMETHYLPHENOL, 2,4-	0.7	4000	10	400	900	4000	100000	10000
DINITROPHENOL, 2,4-	3	90	6	40	90	90	20000	900
DINITROTOLUENE, 2,4-	0.7	7	7	1	2	7	20000	70
DIOXIN	2E-05	2E-05	2E-05	4E-06	6E-06	2E-05	1E-03	2E-04
ENDOSULFAN	0.2	6	0.05	1	3	6	4	60
ENDRIN	0.6	10	1	6	10	10	50	100
ETHYLBENZENE	80	2500	500	500	1000	2500	100000	10000
ETHYLENE DIBROMIDE	0.005	0.04	0.07	0.01	0.02	0.07	100000	0.7
FLUORANTHENE	600	5000	600	900	2000	5000	100	10000
FLUORENE	400	5000	1000	900	2000	5000	1000	10000
HEPTACHLOR	0.7	0.7	0.7	0.1	0.2	0.7	10	7
HEPTACHLOR EPOXIDE	0.3	0.3	0.3	0.06	0.09	0.3	20	3
HEXACHLOROBENZENE	3	3	3	0.7	0.8	3	60	30
HEXACHLOROBUTADIENE	3	3	40	7	10	40	900	400
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)	0.1	2	0.5	0.4	0.6	2	8	20
HEXACHLOROETHANE	30	30	50	6	10	50	50000	500
INDENO(1,2,3-cd)PYRENE	0.7	0.7	0.7	0.7	0.7	0.7	0.3	7
LEAD	600	600	600	300	600	600	300	6000
MERCURY	60	60	60	10	60	60	20	600
METHOXYCHLOR	300	300	30	100	300	300	40	3000
METHYL ETHYL KETONE	0.3	40	40	500	1000	2500	100000	10000
METHYL ISOBUTYL KETONE	0.5	70	70	100	500	1000	100000	10000
METHYL MERCURY	20	20	20	7	20	20	20	200
METHYL TERT BUTYL ETHER	3	200	200	100	500	500	100000	5000
METHYLENE CHLORIDE	0.1	700	700	100	200	700	100000	7000
METHYLNAPHTHALENE, 2-	0.7	20	7	1000	2500	2500	10000	10000
NAPHTHALENE	4	1000	1000	100	2500	2500	20000	10000
NICKEL	700	700	700	300	700	700	1000	7000
PENTACHLOROPHENOL	5	40	40	7	10	40	800	400
PHENANTHRENE	700	2500	100	1000	2500	2500	400	10000
PHENOL	60	800	500	500	1000	2500	100000	10000
POLYCHLORINATED BIPHENYLS	2	2	2	2	2	2	5	100
PYRENE	500	5000	500	700	2000	5000	80	10000
SELENIUM	2500	2500	2500	300	2500	2500	800	10000
SILVER	200	200	200	100	200	200	400	2000
STYRENE	2	20	100	20	30	100	100000	1000
TETRACHLOROETHANE, 1,1,1,2-	0.4	0.5	20	4	5	20	100000	200
TETRACHLOROETHANE, 1,1,2,2-	0.02	0.2	2	0.5	0.6	2	100000	20
TETRACHLOROETHYLENE	0.5	300	500	200	300	1000	50000	10000

--------------------- file: TXINF1-1.wk1, 4/20/94 ---------------------

Table 1.1, continued...

TABLE 1-1 MCP NUMERICAL STANDARDS	Method 1 S-3 Soil Standards 310 CMR 40.0975(6)(c)			Method 2 Direct Contact Soil Standards 310 CMR 40.0985(6)			Methods 2 & 3 Upper Concentration Limits (UCLs) 310 CMR 40.0996(4)	
OIL AND/OR HAZARDOUS MATERIAL	S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-3/GW-3 mg/kg	S-1 mg/kg	S-2 mg/kg	S-3 mg/kg	Groundwater ug/L	Soil ug/g
THALLIUM	100	100	100	8	30	100	4000	1000
TOLUENE	90	500	2500	500	1000	2500	100000	10000
TOTAL PETROLEUM HYDROCARBONS	5000	5000	5000	500	2500	5000	100000	10000
TRICHLOROBENZENE, 1,2,4-	100	900	800	400	1000	1000	6000	10000
TRICHLOROETHANE, 1,1,1-	30	500	500	100	500	500	100000	5000
TRICHLOROETHANE, 1,1,2-	0.3	10	10	2	3	10	100000	100
TRICHLOROETHYLENE	0.4	20	500	70	100	500	100000	5000
TRICHLOROPHENOL, 2,4,5-	3	5000	2	1000	2500	5000	2000	10000
TRICHLOROPHENOL 2,4,6-	3	200	200	40	60	200	100000	2000
VINYL CHLORIDE	0.4	0.3	2	0.3	0.5	2	600	20
XYLENES	800	500	2500	500	1000	2500	100000	10000
ZINC	5000	5000	5000	2500	2500	5000	20000	10000

2.0 DOSE-RESPONSE INFORMATION

This section contains the dose-response information and physical constants for each of the oil or hazardous material for which MCP Method 1 Standards are derived. This information is coupled with the exposure information described in Sections 4 and 5 to develop the standards for each Groundwater and Soil Category.

The dose-response information is divided into three major categories:

- Toxicity information associated with threshold (non-carcinogenic) health effects.
- Toxicity information concerning carcinogenicity, either from human epidemiologic data or from laboratory studies.
- The *<u>R</u>elative* *<u>A</u>bsorption* *<u>F</u>actors* (RAFs) used to relate the toxicity values from the literature to the exposure pathways of concern in this spreadsheet.

The classification of a chemical as a carcinogen does not preclude an evaluation of that same chemical for potential non-carcinogenic health risks.

2.1 THRESHOLD EFFECTS

For non-carcinogenic health effects it is believed that a dose level exists at and below which no adverse health effects would be expected. Such a level is referred to as a ***threshold dose***. While it is impossible to specify a theoretical threshold dose for a given chemical, it is possible to estimate a <u>human</u> sub-threshold dose at which no adverse health effects would be expected. Such a value is typically derived from the No Observable Adverse Effects Level (NOAEL) of an animal study (although human data are used, when available) by application of uncertainty factors (UF) to account for interspecies variation, exposure duration and to protect sensitive populations. Important factors to consider when identifying and using such a sub-threshold dose include:

- the route of administration of the dose (inhalation, oral, dermal contact, etc...)
- the duration of exposure to that dose (lifetime, chronic, subchronic, or acute exposure)
- the absorption efficiency (if any) used to calculate that dose
- the age of the person receiving the dose.

Several types of "sub-threshold dose" values were used to develop the MCP Method 1 Standards. The sources of these values are described in general below, and Table 2.1 provides the specific values. The source for a specific toxicity value may be found using the references adjacent to each value in the table, and the list of references at the end of the table.

For oral and dermal exposures, the U.S. EPA-derived oral Reference Dose (RfD) was used when one was available for the chemical of concern. Chronic RfDs are available from the U.S. EPA's on-line database, the *<u>I</u>ntegrated <u>R</u>isk <u>I</u>nformation <u>S</u>ystem* (IRIS). Subchronic RfDs from the U.S. EPA's *<u>H</u>ealth <u>E</u>ffects <u>A</u>ssessment <u>S</u>ummary <u>T</u>ables* (HEAST) were used for the development of Soil Category S-3 Standards. HEAST also served as a source of US EPA derived chronic RfDs.

For inhalation exposures, the U.S. EPA-derived inhalation Reference Concentration (RfC) was used when one was available for the chemical of concern. Chronic RfCs are available from the U.S. EPA's on-line database, the *Integrated Risk Information System* (IRIS) and the U.S. EPA's *Health Effects Assessment Summary Tables* (HEAST). In the absence of an RfC, the "*Allowable Threshold Concentration*" (MA DEQE, 1989a) was used. The Allowable Threshold Concentration (ATC) is a value derived from the Threshold Effects Exposure Limit (TEL) described in CHEM (MA DEP, 1990c). (The TEL value represents 20% of an allowable concentration, or ATC. Thus the ATC is equal to five times the TEL. The TEL was derived in a manner considering children to be the most sensitive potential receptors.) The inhalation pathway was evaluated only for volatile chemicals in the development of GW-2 standards.

For a limited number of chemicals, an analogous toxicity value was identified or developed by MA DEP Office of Research and Standards staff when a subchronic or chronic RfD or RfC was not available from IRIS or HEAST. The documentation for these values is published elsewhere (MA DEP, 1992a).

2.2 CARCINOGENIC EFFECTS

Unlike the non-carcinogenic health effects, it is generally assumed that there is no threshold dose for carcinogenicity, that there is no dose of a carcinogenic substance (other than no exposure) which is associated with zero risk. The ability of a chemical to increase the incidence of cancer in a target population is described by one of two measures: the ***cancer slope factor*** or the ***unit risk***. The cancer slope factor was used to develop the MCP Method 1 Standards.

The cancer slope factor for a chemical is derived by the EPA's Cancer Assessment Group (CAG). Using data derived from animal studies, the slope factor is an estimate of the upper 95% Confidence Limit of the slope of the dose-response curve extrapolated to low doses. For some chemicals, human epidemiologic data is the basis of an estimate of the carcinogenic potency, although the most common basis of these values is an animal study. The slope factor is given in units of $(mg/kg/day)^{-1}$. It is based upon the concept of a lifetime average daily dose.

The inhalation Unit Risk is the upper 95% Confidence Limit of the mean incremental lifetime cancer risk estimated to result from lifetime exposure to an agent if it is in the air at a concentration of 1 $\mu g/m^3$.

The U.S. EPA derived oral cancer slope factor (CSF) was used to evaluate both oral and dermal exposure to carcinogens. The U.S. EPA's *IRIS* database and the *Health Effects Assessment Summary Tables* served as the primary and secondary sources of the slope factors. Inhalation Unit Risks (from the same sources) were used to evaluate the inhalation exposure pathway for volatile chemicals in the development of GW-2 standards only.

2.3 RELATIVE ABSORPTION FACTORS (RAFs)

The development of the MCP Method 1 Standards used Relative Absorption Factors (RAFs) which have been determined or estimated for each chemical via each route of exposure.

The RAF addresses two major issues:

- the absorption efficiency for the chemical via the route and medium of exposure for which the standard is being developed, and

- the absorption efficiency for the route and medium of exposure in the experimental study which is the basis of the Reference Dose or the Cancer Slope Factor for the chemical in question.

Thus the RAF adjusts the dose (or exposure) estimates based on these ***two*** absorption efficiencies. MA DEQE (1989) and MA DEP (1992) describe the development of RAFs in detail. (The factors were called "*Bioavailability Adjustment Factors*", or "*BAFs*" in the 1989 document.) US EPA (1989a), Appendix A also provides guidance for the "Adjustments For Absorption Efficiency".

2.4 TOXICITY INFORMATION TABLE - Table 2.1.

The following summary table documents the selection and development of individual toxicity values. The list of references is provided at the end of the table.

TABLE 2.1

TOXICITY INFORMATION

TABLE 2-1

TOXICITY INFORMATION & RAFs

OIL AND/OR HAZARDOUS MATERIAL	CAS NUMBER	SUBCHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC INHALATION REFERENCE DOSE (OR SUBSTITUTE) ug/cu m	REF	ORAL CANCER POTENCY FACTOR 1/(mg/kg/day)	CLASS	REF
ACENAPHTHENE	83329	6.0E-01	2	6.0E-02	1					
ACENAPHTHYLENE	208968	4.0E-02	2f	4.0E-02	2f				D	1
ACETONE	67641	1.0E+00	2	1.0E-01	1	8.0E+02	3		D	1
ALDRIN	309002	3.0E-05	2	3.0E-05	1			1.70E+01	B2	1
ANTHRACENE	120127	3.0E+00	2	3.0E-01	1				D	1
ANTIMONY	7440360	4.0E-04	2	4.0E-04	1					
ARSENIC	7440382	3.0E-04	2	3.0E-04	1			1.75E+00	A	1f
BENZENE	71432	5.0E-02	4	5.0E-03	4	9.0E+00	3	2.90E-02	A	1
BENZO(a)ANTHRACENE	56553	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
BENZO(a)PYRENE	50328	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1
BENZO(b)FLUORANTHENE	205992	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
BENZO(g,h,i)PERYLENE	191242	4.0E-02	2f	4.0E-02	2f				D	1
BENZO(k)FLUORANTHENE	207089	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
BERYLLIUM	7440417	5.0E-03	2	5.0E-03	1			4.30E+00	B2	1
BIPHENYL, 1,1-	92524	5.0E-02	2	5.0E-02	1				D	1
BIS(2-CHLOROETHYL)ETHER	111444	NA						1.10E+00	B2	1
BIS(2-CHLOROISOPROPYL)ETHER	39638329	4.0E-02	2	4.0E-02	1			7.00E-02	C	2
BIS(2-ETHYLHEXYL)PHTHALATE	117817	2.0E-02	2	2.0E-02	1	7.0E+00	3	1.40E-02	B2	1
BROMODICHLOROMETHANE	75274	2.0E-02	2	2.0E-02	1			6.20E-02	B2	1
BROMOFORM	75252	2.0E-01	2	2.0E-02	1			7.90E-03	B2	1
BROMOMETHANE	74839	1.4E-02	2	1.4E-03	1	5.0E+00	1		D	1
CADMIUM	7440439	5.0E-04	1a,1e	5.0E-04	1a				ND	1
CARBON TETRACHLORIDE	56235	7.0E-03	2	7.0E-04	1	4.3E+02	3	1.30E-01	B2	1
CHLORDANE	57749	6.0E-05	2	6.0E-05	1	7.0E-01	3	1.30E+00	B2	1
CHLOROANILINE, p-	106478	4.0E-03	2	4.0E-03	1					
CHLOROBENZENE	108907	2.0E-01	2	2.0E-02	1	2.0E+01	2		D	1
CHLOROFORM	67663	1.0E-02	2	1.0E-02	1	6.6E+02	3	6.10E-03	B2	1
CHLOROPHENOL, 2-	95578	5.0E-02	2	5.0E-03	1					
CHROMIUM(III)	16065831	1.0E+00	2	1.0E+00	1					
CHROMIUM(VI)	18540299	2.0E-02	2	5.0E-03	1				ND	2
CHRYSENE	218019	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
CYANIDE	57125	2.0E-02	2	2.0E-02	1				D	1
DIBENZO(a,h)ANTHRACENE	53703	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
DIBROMOCHLOROMETHANE	124481	2.0E-01	2	2.0E-02	1			8.40E-02	C	1
DICHLOROBENZENE, 1,2- (o-DCB)	95501	9.0E-01	2	9.0E-02	1	2.0E+02	2		D	1
DICHLOROBENZENE, 1,3- (m-DCB)	541731	9.0E-01	2a	9.0E-02	1b				D	1
DICHLOROBENZENE, 1,4- (p-DCB)	106467	9.0E-01	2a			8.0E+02	2	2.40E-02	C	2
DICHLOROBENZIDINE, 3,3'-	91941	NA						4.50E-01	B2	1
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)	72548	NA						2.40E-01	B2	1
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)	72559	NA						3.40E-01	B2	1
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)	50293	5.0E-04	2	5.0E-04	1			3.40E-01	B2	1
DICHLOROETHANE, 1,1-	75343	1.0E+00	2	1.0E-01	2	5.0E+02	2		C	1
DICHLOROETHANE, 1,2-	107062	2.0E-01	4	2.0E-02	4	5.5E+01	3	9.10E-02	B2	1
DICHLOROETHYLENE, 1,1-	75354	9.0E-03	2	9.0E-03	1	5.0E+00	3	6.00E-01	C	1
DICHLOROETHYLENE, CIS-1,2-	156592	1.0E-01	2	1.0E-02	2				D	1

--------------- file: TXINF2-1.wk1, 4/20/94 ---------------

TABLE 2-1

TOXICITY INFORMATION & RAFs

OIL AND/OR HAZARDOUS MATERIAL	CAS NUMBER	SUBCHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC INHALATION REFERENCE DOSE (OR SUBSTITUTE) ug/cu m	REF	ORAL CANCER POTENCY FACTOR 1/(mg/kg/day)	CLASS	REF
DICHLOROETHYLENE, TRANS-1,2-	156605	2.0E-01	2	2.0E-02	1					
DICHLOROPHENOL, 2,4-	120832	3.0E-03	2	3.0E-03	1					
DICHLOROPROPANE, 1,2-	78875	NA				4.0E+00	1	6.80E-02	B2	2
DICHLOROPROPENE, 1,3-	542756	3.0E-03	2	3.0E-04	1	2.0E+01	1	1.80E-01	B2	2
DIELDRIN	60571	5.0E-05	2	5.0E-05	1			1.60E+01	B2	1
DIETHYL PHTHALATE	84662	8.0E+00	2	8.0E-01	1				D	1
DIMETHYL PHTHALATE	131113	1.0E+00	2	1.0E+01	2				D	1
DIMETHYLPHENOL, 2,4-	105679	2.0E-01	2	2.0E-02	1					
DINITROPHENOL, 2,4-	51285	2.0E-03	2	2.0E-03	1					
DINITROTOLUENE, 2,4-	121142	2.0E-03	2	2.0E-03	1			6.80E-01	B2	1h
DIOXIN	1746016	NA		NA				1.50E+05	B2	2
ENDOSULFAN	115297	2.0E-04	2	5.0E-05	1j					
ENDRIN	72208	3.0E-04	2	3.0E-04	1				D	1
ETHYLBENZENE	100414	1.0E+00	2	1.0E-01	1	1.0E+03	1		D	1
ETHYLENE DIBROMIDE	106934	2.0E-04	4	2.0E-05	4	2.0E-01	4	8.50E+01	B2	1
FLUORANTHENE	206440	4.0E-01	2	4.0E-02	1				D	1
FLUORENE	86737	4.0E-01	2	4.0E-02	1				D	1
HEPTACHLOR	76448	5.0E-04	2	5.0E-04	1	7.0E-01	3	4.50E+00	B2	1
HEPTACHLOR EPOXIDE	1024573	1.3E-05	2	1.3E-05	1			9.10E+00	B2	1
HEXACHLOROBENZENE	118741	8.0E-04	2	8.0E-04	1			1.60E+00	B2	1
HEXACHLOROBUTADIENE	87683	2.0E-03	2	2.0E-03	1j			7.80E-02	C	1
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)	58899	3.0E-03	2	3.0E-04	1			1.30E+00	B2-C	2
HEXACHLOROETHANE	67721	1.0E-02	2	1.0E-03	1	3.0E+00	3	1.40E-02	C	1
INDENO(1,2,3-cd)PYRENE	193395	4.0E-02	2f	4.0E-02	2f			7.30E+00	B2	1g
LEAD	7439921	7.5E-04	4	7.5E-04	4				B2	1
MERCURY	7439976	3.0E-04	2	3.0E-04	2				D	1
METHOXYCHLOR	72435	5.0E-03	2	5.0E-03	1				D	1
METHYL ETHYL KETONE	78933	5.0E-01	2	6.0E-01	1	1.0E+03	1		D	1
METHYL ISOBUTYL KETONE	108101	5.0E-01	2	5.0E-02	2	8.0E+01	2			
METHYL MERCURY	22967926	3.0E-04	2	3.0E-04	1					
METHYL TERT BUTYL ETHER	1634044	5.2E-02	4	1.0E-01	5	5.0E+02	1			
METHYLENE CHLORIDE	75092	6.0E-02	2	6.0E-02	1	3.0E+03	2	7.50E-03	B2	1
METHYLNAPHTHALENE, 2-	91576	4.0E-02	2f	4.0E-02	2f	7.1E+01	3b			
NAPHTHALENE	91203	4.0E-02	2	4.0E-02	2	7.1E+01	3b		D	1
NICKEL	7440020	2.0E-02	2	2.0E-02	1				ND	2
PENTACHLOROPHENOL	87865	3.0E-02	2	3.0E-02	1	7.0E-02	3	1.20E-01	B2	1
PHENANTHRENE	85018	4.0E-02	2f	4.0E-02	2f				D	1
PHENOL	108952	6.0E-01	2	6.0E-01	1	2.6E+02	3		D	1
POLYCHLORINATED BIPHENYLS (PCBs)	1336363	5.0E-06	4	2.0E-05	6	2.0E-02	3	7.70E+00	B2	1
PYRENE	129000	3.0E-01	2	3.0E-02	1				D	1
SELENIUM	7782492	5.0E-03	2	5.0E-03	1				D	1
SILVER	7440224	5.0E-03	2	5.0E-03	1				D	1
STYRENE	100425	2.0E+00	2	2.0E-01	1	1.0E+03	1	3.00E-02	B2	2k
TETRACHLOROETHANE, 1,1,1,2-	630206	3.0E-02	2	3.0E-02	1			2.60E-02	C	1
TETRACHLOROETHANE, 1,1,2,2-	79345	NA		NA		9.3E+01	3	2.00E-01	C	1

---------------- file: TXINF2-1.wk1, 4/20/94 ----------------

TABLE 2-1

TOXICITY INFORMATION & RAFs

OIL AND/OR HAZARDOUS MATERIAL	CAS NUMBER	SUBCHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC ORAL REFERENCE DOSE (OR SUBSTITUTE) mg/kg/day	REF	CHRONIC INHALATION REFERENCE DOSE (OR SUBSTITUTE) ug/cu m	REF	ORAL CANCER POTENCY FACTOR 1/(mg/kg/day)	CLASS	REF
TETRACHLOROETHYLENE	127184	1.0E-01	2	1.0E-02	1	4.6E+03	3	5.20E-03	C-B2	2h
THALLIUM	7440280	7.0E-04	2	7.0E-05	2					
TOLUENE	108883	2.0E+00	2	2.0E-01	1	4.0E+02	1		D	1
TOTAL PETROLEUM HYDROCARBONS	NA	3.0E-01								
TRICHLOROBENZENE, 1,2,4-	120821	1.0E-02	2	1.0E-02	1	9.0E+00	2		D	1
TRICHLOROETHANE, 1,1,1-	71556	9.0E-01	2	9.0E-02	2	1.0E+03	2		D	1
TRICHLOROETHANE, 1,1,2-	79005	4.0E-02	2	4.0E-03	1	7.4E+01	3	5.70E-02	C	1
TRICHLOROETHYLENE	79016	2.0E-02	4	2.0E-03	4	1.8E+02	3	1.10E-02	C-B2	2h
TRICHLOROPHENOL, 2,4,5-	95954	1.0E+00	2	1.0E-01	1					
TRICHLOROPHENOL 2,4,6-	88062	NA		NA				1.10E-02	B2	1
VINYL CHLORIDE	75014	1.0E-03	4	1.0E-03	4	1.7E+01	3	1.90E+00	A	2
XYLENES (Mixed Isomers)	1330207	4.0E+00	2	2.0E+00	1	3.0E+02	2		D	1
ZINC	7440666	3.0E-01	2	3.0E-01	1				D	1

file: TXINF2-1.wk1, 4/20/94

Table 2.1, continued...

TABLE 2-1

TOXICITY INFORMATION & RAFs

OIL AND/OR HAZARDOUS MATERIAL	INHALATION CANCER UNIT RISK 1/(ug/cu m)	CLASS	REF	RAF, SUB-CHRONIC SOIL INGEST	RAF, SUB-CHRONIC SOIL DERMAL	RAF CHRONIC SOIL INGEST	RAF CHRONIC SOIL DERMAL	RAF CANCER SOIL INGEST	RAF CANCER SOIL DERMAL	RAF CHRONIC WATER INGEST	RAF CANCER WATER INGEST
				RELATIVE ABSORPTION FACTORS (RAFs)							
ACENAPHTHENE				1	0.2	1	0.2	NC	NC	1	NC
ACENAPHTHYLENE				0.91	0.18	0.91	0.18	NC	NC	0.91	NC
ACETONE		D	1	1	0.1	1	0.1	NC	NC	1	NC
ALDRIN	4.9E-03	B2	1	1	0.25	1	0.25	1	0.25	1	1
ANTHRACENE				1	0.29	1	0.29	NC	NC	1	NC
ANTIMONY				1	0.1	1	0.1	NC	NC	1	NC
ARSENIC				1	0.03	1	0.03	1	0.03	1	1
BENZENE	8.3E-06	A	1	1	0.08	1	0.08	1	0.08	1	1
BENZO(a)ANTHRACENE				0.91	0.18	0.91	0.18	1	0.2	0.91	1
BENZO(a)PYRENE	1.7E-03		2	0.91	0.18	0.91	0.18	1	0.2	0.91	1
BENZO(b)FLUORANTHENE				0.91	0.18	0.91	0.18	1	0.2	0.91	1
BENZO(g,h,i)PERYLENE				0.91	0.18	0.91	0.18	NC	NC	0.91	NC
BENZO(k)FLUORANTHENE				0.91	0.18	0.91	0.18	1	0.2	0.91	1
BERYLLIUM				1	0.03	1	0.03	1	0.03	1	1
BIPHENYL, 1,1-				1	0.08	1	0.08	NC	NC	1	NC
BIS(2-CHLOROETHYL)ETHER	3.3E-04	B2	1	NC	NC	NC	NC	1	1	NC	1
BIS(2-CHLOROISOPROPYL)ETHER	1.0E-05	C	2	1	1	1	1	1	1	1	1
BIS(2-ETHYLHEXYL)PHTHALATE	1.3E-06		chem	1	0.02	1	0.02	1	0.02	1	1
BROMODICHLOROMETHANE				1	0.1	1	0.1	1	0.1	1	1
BROMOFORM	1.1E-06	B2	1	1	0.11	1	0.11	1	0.1	1	1
BROMOMETHANE				1	0.1	1	0.1	NC	NC	1	NC
CADMIUM				1	0.14	1	0.14	NC	NC	1	NC
CARBON TETRACHLORIDE	1.5E-05	B2	1	1	0.1	1	0.1	1	0.1	1	1
CHLORDANE	3.7E-04	B2	1	1	0.05	1	0.05	1	0.05	1	1
CHLOROANILINE, p-				1	0.1	1	0.1	NC	NC	1	NC
CHLOROBENZENE		D	1	1	0.1	1	0.1	NC	NC	1	NC
CHLOROFORM	2.3E-05	B2	1	1	0.1	1	0.1	1	0.1	1	1
CHLOROPHENOL, 2-				1	0.26	1	0.26	NC	NC	1	NC
CHROMIUM(III)				1	0.04	1	0.04	NC	NC	1	NC
CHROMIUM(VI)				1	0.09	1	0.09	NC	NC	1	NC
CHRYSENE				0.91	0.18	0.91	0.18	1	0.2	0.91	1
CYANIDE				1	0.3	1	0.3	NC	NC	1	NC
DIBENZO(a,h)ANTHRACENE				0.91	0.08	0.91	0.08	1	0.09	0.91	1
DIBROMOCHLOROMETHANE				1	0.1	1	0.1	1	0.1	1	1
DICHLOROBENZENE, 1,2- (o-DCB)				1	0.1	1	0.1	NC	NC	1	NC
DICHLOROBENZENE, 1,3- (m-DCB)				NC	NC	1	0.1	NC	NC	1	NC
DICHLOROBENZENE, 1,4- (p-DCB)				NC	NC	1	0.1	1	0.1	NC	1
DICHLOROBENZIDINE, 3,3'-				NC	NC	NC	NC	1	0.54	NC	1
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)				NC	NC	NC	NC	1	0.2	NC	1
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)				NC	NC	NC	NC	1	0.2	NC	1
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)	9.7E-05	B2	1	1	0.2	1	0.2	1	0.2	1	1
DICHLOROETHANE, 1,1-		C	2	1.3	0.13	1.3	0.13	NC	NC	1.3	NC
DICHLOROETHANE, 1,2-	2.6E-05	B2	2	1	0.1	1	0.1	1	0.1	1	1
DICHLOROETHYLENE, 1,1-	5.0E-05	C	1	1	0.1	1	0.1	1.02	0.102	1	1.02
DICHLOROETHYLENE, CIS-1,2-				1	0.1	1	0.1	NC	NC	1	NC

---------------- file: TXINF2-1.wk1, 4/20/94 ----------------

Table 2.1, continued...

TABLE 2-1

TOXICITY INFORMATION & RAFs

OIL AND/OR HAZARDOUS MATERIAL	INHALATION CANCER UNIT RISK 1/(ug/cu m)	CLASS	REF	RAF, SUB-CHRONIC SOIL INGEST	RAF, SUB-CHRONIC SOIL DERMAL	RAF CHRONIC SOIL INGEST	RAF CHRONIC SOIL DERMAL	RAF CANCER SOIL INGEST	RAF CANCER SOIL DERMAL	RAF CHRONIC WATER INGEST	RAF CANCER WATER INGEST
				RELATIVE ABSORPTION FACTORS (RAFs)							
DICHLOROETHYLENE, TRANS-1,2-				1	0.1	1	0.1	NC	NC	1	NC
DICHLOROPHENOL, 2,4-				1	0.4	1	0.4	NC	NC	1	NC
DICHLOROPROPANE, 1,2-	1.9E-05	B2	chem	NC	NC	NC	NC	1	0.2	NC	1
DICHLOROPROPENE, 1,3-	3.7E-05	B2	2	1	0.2	1	0.2	1	0.2	1	1
DIELDRIN	4.6E-03	B2	1	1	0.25	1	0.25	1	0.25	1	1
DIETHYL PHTHALATE				1	0.02	1	0.02	NC	NC	1	NC
DIMETHYL PHTHALATE				1	0.07	1	0.07	NC	NC	1	NC
DIMETHYLPHENOL, 2,4-				1	0.26	1	0.26	NC	NC	1	NC
DINITROPHENOL, 2,4-				1	0.26	1	0.26	NC	NC	1	NC
DINITROTOLUENE, 2,4-				1	0.13	1	0.13	1	0.13	1	1
DIOXIN	3.3E+01	B2	2	NC	NC	NC	NC	1	0.2	NC	1
ENDOSULFAN				1	0.2	1	0.2	NC	NC	1	NC
ENDRIN				1	0.25	1	0.25	NC	NC	1	NC
ETHYLBENZENE		D	1	1	0.2	1	0.2	NC	NC	1	NC
ETHYLENE DIBROMIDE	2.2E-04	B2	1	1	0.1	1	0.1	1	0.1	1	1
FLUORANTHENE				1	0.2	1	0.2	NC	NC	1	NC
FLUORENE				1	0.2	1	0.2	NC	NC	1	NC
HEPTACHLOR	1.3E-03	B2	1	1	0.2	1	0.2	1	0.2	1	1
HEPTACHLOR EPOXIDE	2.6E-03	B2	1	1	0.2	1	0.2	1	0.2	1	1
HEXACHLOROBENZENE	4.6E-04	B2	1	1	0.13	1	0.13	1	0.13	1	1
HEXACHLOROBUTADIENE	2.2E-05	C	1	1	0.2	1	0.2	1	0.2	1	1
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)				1	0.2	1	0.2	1	0.2	1	1
HEXACHLOROETHANE	4.0E-06	C	2	1	1	1	1	1	1	1	1
INDENO(1,2,3-cd)PYRENE				0.91	0.18	0.91	0.18	1	0.2	0.91	1
LEAD				0.5	0.006	0.5	0.006	NC	NC	0.5	NC
MERCURY				1	0.05	1	0.05	NC	NC	1	NC
METHOXYCHLOR				1	0.2	1	0.2	NC	NC	1	NC
METHYL ETHYL KETONE		D	1	1	0.1	1	0.1	NC	NC	1	NC
METHYL ISOBUTYL KETONE				1	0.1	1	0.1	NC	NC	1	NC
METHYL MERCURY				1	0.2	1	0.2	NC	NC	1	NC
METHYL TERT BUTYL ETHER				1	0.1	1	0.1	NC	NC	1	NC
METHYLENE CHLORIDE	4.7E-07	B2	1	1	0.1	1	0.1	1	0.1	1	1
METHYLNAPHTHALENE, 2-				1	0.1	1	0.1	NC	NC	1	NC
NAPHTHALENE		D	1	1	0.1	1	0.1	NC	NC	1	NC
NICKEL				1	0.35	1	0.35	NC	NC	1	NC
PENTACHLOROPHENOL				1	0.11	1	0.11	1	0.11	1	1
PHENANTHRENE				0.91	0.18	0.91	0.18	NC	NC	0.91	NC
PHENOL				1	0.26	1	0.26	NC	NC	1	NC
POLYCHLORINATED BIPHENYLS (PCBs)				0.85	0.067	0.85	0.067	0.85	0.067	1	1
PYRENE				1	0.2	1	0.2	NC	NC	1	NC
SELENIUM				1	0.002	1	0.002	NC	NC	1	NC
SILVER				1	0.25	1	0.25	NC	NC	1	NC
STYRENE	5.7E-07	B2	2	1	0.2	1	0.2	1	0.2	1	1
TETRACHLOROETHANE, 1,1,1,2-	7.4E-06	C	1	1	1.4	1	1.4	1	1.4	1	1
TETRACHLOROETHANE, 1,1,2,2-	5.8E-05	C	1	NC	NC	NC	NC	1	1.4	NC	1

--------------- file: TXINF2-1.wk1, 4/20/94 ---------------

Table 2.1, continued...

TABLE 2-1

TOXICITY INFORMATION & RAFs

OIL AND/OR HAZARDOUS MATERIAL	INHALATION CANCER UNIT RISK 1/(ug/cu m)	CLASS	REF	RELATIVE ABSORPTION FACTORS (RAFs) RAF, SUB-CHRONIC SOIL INGEST	RAF, SUB-CHRONIC SOIL DERMAL	RAF CHRONIC SOIL INGEST	RAF CHRONIC SOIL DERMAL	RAF CANCER SOIL INGEST	RAF CANCER SOIL DERMAL	RAF CHRONIC WATER INGEST	RAF CANCER WATER INGEST
TETRACHLOROETHYLENE	5.2E-07	C-B2	2h	1	0.1	1	0.1	1	0.1	1	1
THALLIUM				1	0.01	1	0.01	NC	NC	1	NC
TOLUENE		D	1	1	0.12	1	0.12	NC	NC	1	NC
TOTAL PETROLEUM HYDROCARBONS				1	1	1	1	NC	NC		
TRICHLOROBENZENE, 1,2,4-				1	0.08	1	0.08	NC	NC	1	NC
TRICHLOROETHANE, 1,1,1-		D	1	1	0.1	1	0.1	NC	NC	1	NC
TRICHLOROETHANE, 1,1,2-	1.6E-05	C	1	1	1	1	1	1	1	1	1
TRICHLOROETHYLENE	1.7E-06	C-B2	2h	1	0.1	1	0.1	1	0.1	1	1
TRICHLOROPHENOL, 2,4,5-				1	0.26	1	0.26	NC	NC	1	NC
TRICHLOROPHENOL 2,4,6-	3.1E-06	B2	1	NC	NC	NC	NC	1	0.26	NC	1
VINYL CHLORIDE	8.4E-05	A	2	1	0.1	1	0.1	1.53	0.16	1	1.53
XYLENES (Mixed Isomers)		D	1	1	0.12	1	0.12	NC	NC	1	NC
ZINC				1	0.02	1	0.02	NC	NC	1	NC

References for Toxicity Values and Constants on Spreadsheet

Reference #	Description
1.	U.S. EPA, Integrated Risk Information System (IRIS). On-line search: current as of July 1, 1993.
1.a.	The chronic oral RfD for drinking water (from IRIS) is listed here as the oral RfD for cadmium.
1.b.	The chronic oral RfD for 1,2-Dichlorobenzene has been used as the chronic oral RfD equivalent for 1,3-Dichlorobenzene.
1.e.	The chronic oral RfD (from IRIS) has been used here as a subchronic oral RfD equivalent.
1.f.	This oral Cancer Slope Factor equivalent for arsenic is back-calculated from a drinking water Unit Risk Value from IRIS.
1.g.	This Cancer Slope Factor or Unit Risk for benzo(a)pyrene (from IRIS) has been applied to the seven PAH compounds which are designated as category A, B1, B2 or C carcinogens.
1.h.	The oral cancer slope factor for a mix of 2,4- and 2,6- Dinitrotoluene (from IRIS) has been used as the cancer slope factor equivalent for pure 2,4-Dinitrotoluene.
1.j.	This value was recently withdrawn form IRIS, although many consultants may continue to use it, lacking any new information.
2.	U.S. EPA Health Effects Assessment Summary Tables (HEAST), Annual FY-1992. (OERR 9200.6-303 (92-1), NTIS No. PB92-921199) January/July 1992.
2.a.	This subchronic oral RfD (from HEAST) for 1,2-Dichlorobenzene has been used as the subchronic oral RfD equivalent for 1,3- and 1,4- Dichlorobenzene.
2.b.	This subchronic oral RfD (from HEAST) for naphthalene has been used as the subchronic oral RfD equivalent for all PAH compounds for which subchronic oral RfDs are unavailable.
2.d.	Note!! HEAST lists TWO oral RfDs. Call for more information.
2.f.	The chronic oral RfD for naphthalene (from HEAST) has been used as the chronic RfD equivalent for all PAH compounds for which chronic oral RfDs are unavailable.
2.h.	This Cancer Slope Factor or Unit Risk was taken from a fact sheet distributed by the U.S. EPA Superfund Health Risk Technical Support Center at ECAO-Cincinnati, current as of September 2, 1992.
2.j.	HEAST has adopted the IRIS chronic oral RfD as the subchronic oral RfD.
2.k.	This value has been withdrawn from HEAST, although many consultants may continue to use it, lacking any new information. Consult HEAST for any additional information.
3.	Allowable Threshold Concentrations (ATCs) from MA DEQE (1989a), Guidance for Disposal Site Risk Characterization and Related Phase II Activities - In Support of the Massachusetts Contingency Plan.
3.b.	The ATC for "total concentration of naphthalene and 2-methylnaphthalene" is used here as the ATC for this chemical.
3.c.	The chronic inhalation ATC for naphthalene has been used as the chronic inhalation RfC equivalent for all PAH compounds for which chronic inhalation RfCs are unavailable.
4.	Developed for the *Risk Assessment ShortForm - Residential Scenario* (MA DEP, 1992) by MA DEP staff. Documentation of this value may be found in that document.
5.	The chronic oral RfD for Methyl tert-Butyl Ether is based on Drinking Water Guidelines promulgated by the ORS in October, 1992.
6.	The chronic oral RfD for Arachlor 1254, developed by DEP ORS in a May 10, 1993 memo, has been used as the chronic oral RfD for PCBs as a group.
SES	These values have been developed using the SESOIL model.

Reference #	Description
NA	Not Available
NC	Not Calculated.
10.	Owen, 1990. "Literature Derived Absorption Coefficients for 39 Chemicals via Oral and Inhalation Routes of Exposure"; Regulatory Toxicology and Pharmacology; pp. 237-252; November, 1990.
11.	United States Environmental Protection Agency (USEPA), 1986. "Superfund Public Health Evaluation Manual"; U.S. Environmental Protection Agency; Office of Emergency and Remedial Response, EPA/540/1-86/060 (OSWER Directive 9285.4-1); Washington, D.C., October 1986.
12.	USEPA, 1992. "Dermal Exposure Assessment: Principles and Applications"; U.S. Environmental Protection Agency; Office of Research and Development, EPA/600/8-91/011B; Washington, D.C., January 1992.
13.	ATSDR, "Toxicological Profile for ______________"; Agency for Toxic Substances and Disease Registry, U.S. Public Health Service. The ATSDR profile for the chemical of interest was used as a source of this value.
14.	USEPA Test Methods for Evaluating Solid Waste, SW-846, Third Edition (Revision O), November 1986.
14.a.	USEPA Method 8240.
14.b.	USEPA Method 8080.
14.c.	USEPA Method 8270.
14.d.	USEPA Method 6010.
14.e.	USEPA Method 525.1.
14.f.	USEPA Method 524.1.
14.g.	USEPA Method 524.2.
14.h.	USEPA Method 7196.
14.i.	USEPA Method 7470.
15.	Guide to Environmental Analytical Methods, Robert E. Wagner, editor; Genium Publishing Corporation, Schenectady, NY; 1992.
15.a.	USEPA Method 335.
15.b.	USEPA Method 200.7.
15.c.	USEPA Method 508.
15.d.	USEPA Method 625.
16.	From CLP Statement of Work for Inorganic Analytes, 8/90, Document Number ILM01.1
17.	Standard Methods for the Examination of Water and Wastewater, 17th edition; Water Environment Federation.
18.	Federal Register 40 CFR 141:23:3579 (January 30, 1991).
19.	USEPA Method 1613.
20.	U.S. Department of Defense, 1989
21.	U.S. EPA Draft Health Advisory for Methyl t-Butyl Ether, 1989.
22.	Oregon Department of Environmental Quality, Development of Generic Soil Cleanup Levels Based On Analysis Of The Leachate Pathway, May 12, 1992.
23.	See Appendix G: Application of SESOIL Model
24.	Handbook of Environmental Data on Organic Chemicals, 2nd edition, Karel Verschueren; Van Nostrand Reinhold Co. Inc., NY; 1983.

Reference #	Description
25.	Compilation of Odor and Taste Threshold Values Data, F.A. Fazzalari, editor; ASTM Data Service DS48A; 1978.
27.	USEPA, 1992. "Reference Guide to Odor Thresholds for Hazardous Air Pollutants Listed in the Clean Air Act Amendment of 1990", U.S. Environmental Protection Agency; Office of Research and Development, EPA/600/R-92/047; Washington, D.C., March 1992.
28.	USEPA, 1992. "Indoor Air Quality Database for Organic Compounds", U.S. Environmental Protection Agency; Research Triangle Park, NC, February 1992.
29.	Risk Reduction Engineering Laboratory (RREL) Treatability Database, Version 4.0.
30.	U.S. Department of Defense, 1991. "Defense Priority Model Users Manual", FY 1992 version; Washington, D.C.
calc	Calculated value

3.0 CONSIDERATION OF PQL, BACKGROUND, SOLUBILITY, ODOR AND CEILING CONCENTRATIONS

The methodology for developing the MCP Numerical Standards considered the Practical Quantitation Limit (PQL) and background levels for the oil or hazardous material in each medium, the solubility of the chemical in water and, when available, the chemical's odor threshold and calculated odor index. In addition, *ceiling concentrations* were established to address non-quantifiable risks to public welfare and the environment.

3.1 PRACTICAL QUANTITATION LIMITS

The PQL is the lowest quantitation level of a chemical that can be reliably achieved among laboratories within the specified limits of precision and accuracy of a given analytical method during routine laboratory operating conditions. Table 3.1 lists the PQLs identified for each oil or hazardous material in soil and groundwater, referencing the specific analytical method. A discussion on the selection of PQLs is described in Appendix G.

The risk-based concentrations generated for each oil or hazardous material were compared to the PQL to insure that the Method 1 standard can be measured with reliability. Note that the PQLs selected are *not* the lowest quantitation limit: Method Detection Limits (MDLs) are lower, but the quantification of a chemical's concentration at those levels is less reliable.

3.2 BACKGROUND

The level of oil or hazardous material which would exist in the absence of the site ("background") is considered in a number of ways in the MCP, including a condition:

- If the concentration of an oil and/or hazardous material at the disposal site is at or below background levels, then that oil and/or hazardous material shall be considered to pose No Significant Risk. (310 CMR 40.0902(3))

In developing the Method 1 Standards, it was decided that, when the information is readily available, the numerical standards should not be set at a level less than an established background concentration. **This partially addresses the intent of the regulation paraphrased above.** As described below, the chosen background levels represent upper percentiles of a "natural" background distribution.

The use of background levels in this manner in the development of a limited number of standards does not eliminate the MCP requirement for identifying site-specific background levels (310 CMR 40.0904(2)(b)). The Department intends to issue more detailed guidance in this area.

Background may be chosen as the remedial goal primarily for three reasons:

- Remediation to background levels may be chosen to eliminate the risk characterization entirely (310 CMR 40.0901(3)), to minimize the complexity of the risk characterization process, or to achieve a Class A-1 Response Action Outcome (310 CMR 40.1036(1)).

- Remediation to background levels for all or some oil or hazardous materials may be chosen because background levels prevent the attainment of specified risk-based goals (310 CMR 40.0902(3)).

- The feasibility of remediation to background levels has been evaluated as part of a remedial response action, and it is determined to be feasible (310 CMR 40.0860).

There is not one concentration of a chemical, of course, which can correctly be labelled *the* background level. Hundreds of years of human activities have only broadened the range of concentrations reported as "background", and this range is best thought of as a statistical distribution. For the purposes of many environmental regulations, however, we often select point values from the range of representative background levels, and consider these to be representative of background. The use of such point-value "background" levels is essentially a short-cut method which allows consideration of background when little analytical data is available. When sufficient information has been collected (enough site-specific background and on-site samples to establish and describe distributions for each), comparisons to background can be accomplished through statistical tests of the sample populations. For the consideration of background at c.21E sites such an assessment should be the norm.

The listed point values have been chosen to represent concentrations consistent with the majority of "natural" background conditions, and they range from the 75^{th} to 95^{th} percentile values of the data sets examined (depending upon the information available for that data set). Given the wide ranges seen in distributions of background concentrations it is clear that the choice of a point value within that range balances the need to eliminate background chemicals with the need to retain for evaluation those chemicals whose presence is related to the disposal practices at the site but which are reported at relatively low to moderate concentrations. [The terms "low" to "moderate" are used here in a subjective sense to describe concentrations which may be in or slightly above the upper bounds of the background range. The terms imply nothing about potential risks.] It is inevitable that some chemicals which are unrelated to the site disposal but present at concentrations at the high end of the background range will not automatically be considered as "background" using these point values, and a site-specific background determination remains an option. Conversely, some chemicals which are related to the disposal practices at the site (and are not background) will be considered to be "background" using these point values, but it is expected that the number of such instances will be relatively small. The goal is to minimize both kinds of error.

The background concentrations in soil and groundwater listed in Table 3.1 are taken directly from the Documentation for the Residential ShortForm (MA DEP, 1992a), and the derivation of the values may be found therein. The background indoor air concentrations include those found in the ShortForm and data for additional chemicals from the same sources (Shah, 1988 and Stolwijk, 1990).

3.3 SOLUBILITY

Each oil or hazardous material considered in the development of the Method 1 standards is soluble in groundwater to a greater or lesser degree. From a practical aspect, solubility is a concern if the calculated allowable level (based upon an analysis of risk) is higher than what could be expected in the groundwater based upon the material's solubility.

As a general rule, if the calculated Method 1 groundwater standard is greater than the chemical's solubility, then a value of one-half the solubility is adopted as the Method 1 standard.

The solubility of each OHM is listed in Table 3.1. Values are not listed for the metals due to compound-dependent variability.

This rule would not be necessary if environmental analyses never reported concentrations of oil or hazardous materials greater than their solubility. Occasionally, however, analytical results may be greater than the chemical's published solubility due to laboratory contamination of the sample, soil particulates in the water, or the presence of undissolved chemical (free product). Under such circumstances, the resulting concentrations may not be comparable to the Method 1 standards, and a more detailed investigation should follow.

3.4 ODOR

The potential for odor problems is often cited as a relevant public welfare issue at M.G.L. c.21E sites. Odor thresholds are therefore considered in the setting of groundwater and soil standards. When available, the odor thresholds for the oil and hazardous materials listed were identified and added as a limiting factor (in addition to risk-based concentration, solubility, background, and PQL) in the derivation of the numerical standards.

The odor threshold used here is the concentration at which 50% of the population can detect a compound's odor. Odor thresholds are identified for contaminants in water (μg/l) for the GW-1 standards, and for contaminants in air (ppm) for the GW-2 standards. (The GW-2 standards are based upon volatilization of OHM to air.)

For soil, a chemical's ***odor index*** is identified and used to determine the appropriate ceiling level to be applied in the calculation of the Method 1 soil standards. The odor index value is determined by dividing a compound's vapor pressure, in Torr at 20 - 30 degrees Celsius, by its odor threshold in ppm in air, thus providing a relative ranking of the chemical's potential for creating nuisance conditions due to the odor of volatilized material.

3.5 CEILING CONCENTRATIONS

Ceiling concentrations have been identified for contaminants in soil and groundwater. As described in the methodologies presented in Sections 4.0 and 5.0, these concentrations are used to limit excessive residual concentrations in situations where the health-risk calculations (which consider a limited number of exposure pathways and endpoints) result in relatively high allowable levels. Ceiling concentrations truncate the range of the numerical standards on the high end as background and Practical Quantitation Limits truncate the range on the low end.

3.5.1 Ceiling Concentrations in Groundwater

The ceiling concentrations in groundwater noted in the general methodologies described in Section 4.0 are set at a concentration of 50,000 μg/liter, or 0.005%. The ceiling concentration serves two main purposes. First, in areas of current or future drinking water sources, it serves to minimize potential organoleptic (taste, odor) effects. Second, the ceiling concentration provides an upper limit on allowable groundwater contamination which may pose a risk to public welfare and the environment. Such a ceiling will act to minimize continued degradation of the groundwater as a general resource and to minimize the incremental increases to anthropogenic background.

3.5.2 Ceiling Concentrations in Soil

The ceiling concentrations in soil noted in the general methodology presented in Section 5.0 are set considering the *odor index* of the chemical, the volatility of the chemical, and the soil category.

The odor index developed for a chemical is simply the ratio of the vapor pressure (VP) for the chemical, measured at approximately 20° to 30° Celsius, and the 50th percentile odor recognition threshold ($ORT_{50\%}$). Chemicals with a relatively high odor index have correspondingly lower ceiling concentrations.

$$Odor\ Index = \frac{VP_{20°-30°}}{ORT_{50\%}} \qquad (1)$$

Volatile chemicals (i.e., those with vapor pressure greater than 1 Torr at approximately 20° to 30° Celsius) are also assigned relatively low ceiling concentrations.

The ceiling concentrations serve two main purposes. First, in high exposure potential areas (category S-1), the ceiling concentrations provide an upper limit for chemicals which may pose a risk to public health through an inhalation pathway. Second, the ceiling concentrations provide an upper limit on allowable soil contamination which may pose a risk to public welfare and the environment. Such a ceiling will act to minimize continued degradation of soil as a general resource and to minimize the incremental increases to anthropogenic background.

The following ceiling concentrations have been applied in the development of the Method 1 and Method 2 Soil Standards:

SOIL CATEGORY	CRITERIA	CEILING VALUE ADOPTED
Category S-1	Odor Index ≥ 100, *or* Vapor Pressure ≥ 1 Torr	100 μg/g
	0.1 ≤ Odor Index < 100	500 μg/g
	Odor Index < 0.1	1,000 μg/g
Category S-2	Odor Index ≥ 100, *or* Vapor Pressure ≥ 1 Torr	500 μg/g
	0.1 ≤ Odor Index < 100	1,000 μg/g
	Odor Index < 0.1	2,500 μg/g
Category S-3	Vapor Pressure ≥ 1 Torr	500 μg/g
	Odor Index ≥ 100	1,000 μg/g
	0.1 ≤ Odor Index < 100	2,500 μg/g
	Odor Index < 0.1	5,000 μg/g

TABLE 3.1

TABLE 3-1

PQLs, BACKGROUND, SOLUBILITY, ODOR DATA & OTHER PHYSICAL CONSTANTS

OIL AND/OR HAZARDOUS MATERIAL	CAS NUMBER	SOIL BACK-GROUND mg/kg	GROUND WATER BACK-GROUND ug/L	INDOOR AIR BACK-GROUND ug/cu m	SOIL PQL mg/kg	REF	WATER PQL ug/L	REF	ODOR THRESHOLD ug/m3	ODOR THRESHOLD ppm	REF	VAPOR PRESSURE (Torr@20-30C)	REF
ACENAPHTHENE	83329	0.5			0.66	14c	10	14c		0.08	13		
ACENAPHTHYLENE	208968	0.5			0.66	14c	0.5	14e				2.9E-02	13
ACETONE	67641			6	0.1	14a	100	14a	30862	13	13	270	29
ALDRIN	309002				0.00268	14b	0.5	14e	263		28	2.3E-05	29
ANTHRACENE	120127	0.5			0.66	14c	0.5	14e				1.7E-05	13
ANTIMONY	7440360				6.4	14d	32	15b					
ARSENIC	7440382	32	5.5		10.6	14d	50	17					
BENZENE	71432			21	0.005	14a	0.5	14f	4890	1.5	13	95	29
BENZO(a)ANTHRACENE	56553	0.5			0.66	14c	1	14e				5.0E-09	29
BENZO(a)PYRENE	50328	0.5			0.66	14c	0.5	14e				5.0E-09	29
BENZO(b)FLUORANTHENE	205992	0.5			0.66	14c	1	14e					
BENZO(g,h,i)PERYLENE	191242	0.5			0.66	14c	0.5	14e				1.0E-10	29
BENZO(k)FLUORANTHENE	207089	0.5			0.66	14c	1	14e				9.59E-11	29
BERYLLIUM	7440417				0.06	14d	0.3	15b					
BIPHENYL, 1,1-	92524				0.05	14c	0.1	14e	60	9.5E-03	27		
BIS(2-CHLOROETHYL)ETHER	111444				0.66	14c	28.5	15d	287	4.9E-02	13	7.1E-01	29
BIS(2-CHLOROISOPROPYL)ETHER	39638329				0.66	14c	28.5	15d	2240	0.32	24	8.5E-01	24
BIS(2-ETHYLHEXYL)PHTHALATE	117817				0.66	14c	4	14e					
BROMODICHLOROMETHANE	75274				0.005	14a	2.5	14f				50	29
BROMOFORM	75252				0.005	14a	3.5	14f	13450	1.3	13	5.6	29
BROMOMETHANE	74839				0.01	14a	0.55	14g	80000	20	13	1420	29
CADMIUM	7440439		4.2		0.8	14d	4	15b					
CARBON TETRACHLORIDE	56235			1	0.005	14a	1.5	14f	63000	10	13	113	29
CHLORDANE	57749				0.00938	14b	1.5	14e	8.4		28	1.0E-05	29
CHLOROANILINE, p-	106478				1.3	14c	20	14c				1.5E-02	29
CHLOROBENZENE	108907			10	0.005	14c	0.5	14f	1000	0.22	13	11.8	29
CHLOROFORM	67663			3	0.005	14a	1	14f	421600	85	13	160	29
CHLOROPHENOL, 2-	95578				0.66	14c	10	14c	19	3.6E-03	24		
CHROMIUM(III)	16065831				1.4	14d	7	14d					
CHROMIUM(VI)	18540299	105				14h	0.5	14h					
CHRYSENE	218019	0.5			0.66	14c	1.5	14e				6.3E-09	29
CYANIDE	57125				1	16	0.1	15a	652	0.58	13	620	24
DIBENZO(a,h)ANTHRACENE	53703	0.5			0.66	14c	0.5	14e				1.0E-10	13
DIBROMOCHLOROMETHANE	124481				0.005	14a	2	14f				76	13
DICHLOROBENZENE, 1,2- (o-DCB)	95501			1	0.66	14c	5	14f	305000	50	24	1.5	29
DICHLOROBENZENE, 1,3- (m-DCB)	541731				0.66	14c	0.6	14g					
DICHLOROBENZENE, 1,4- (p-DCB)	106467			0.5	0.66	14c	0.2	14g	1100	0.18	13	1.8	29
DICHLOROBENZIDINE, 3,3'-	91941				1.3	14c	82.5	15d				4.5E-09	13
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)	72548				0.00737	14b	0.0125	15c				1.0E-06	29
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)	72559				0.00268	14b	0.05	15c				6.5E-06	29
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)	50293				0.00804	14b	0.3	15c				1.5E-07	29
DICHLOROETHANE, 1,1-	75343				0.005	14a	1	14f	125000	500	13	234	29
DICHLOROETHANE, 1,2-	107062				0.005	14a	1	14f	2424	6	13	79	29
DICHLOROETHYLENE, 1,1-	75354				0.005	14a	1	14f	125000	500	13	591	29
DICHLOROETHYLENE, CIS-1,2-	156592				0.005	14a	0.6	14g				202	29
DICHLOROETHYLENE, TRANS-1,2-	156605				0.005	14a	0.3	14g	67320	17	13	331	29
DICHLOROPHENOL, 2,4-	120832				0.66	14c	13.5	15d	1400.7	0.21	13	6.7E-02	13
DICHLOROPROPANE, 1,2-	78875				0.005	14a	1	14f	1190.5	0.25	13	42	29

file: TXINF3-1.wk1, 4/20/94

TABLE 3-1

PQLs, BACKGROUND, SOLUBILITY, ODOR DATA & OTHER PHYSICAL CONSTANTS

OIL AND/OR HAZARDOUS MATERIAL	CAS NUMBER	SOIL BACK-GROUND mg/kg	GROUND WATER BACK-GROUND ug/L	INDOOR AIR BACK-GROUND ug/cu m	SOIL PQL mg/kg	REF	WATER PQL ug/L	REF	ODOR THRESHOLD ug/m3	ODOR THRESHOLD ppm	REF	VAPOR PRESSURE (Torr@20-30C)	REF
DICHLOROPROPENE, 1,3-	542756				0.005	14a	5	14a	4610	1	13	43	29
DIELDRIN	60571				0.00134	14b	0.1	15c				1.8E-07	29
DIETHYL PHTHALATE	84662				0.66	14c	4	14e					
DIMETHYL PHTHALATE	131113				0.66	14c	1.5	14e					
DIMETHYLPHENOL, 2,4-	105679				0.66	14c	13.5	15d	1		24		
DINITROPHENOL, 2,4-	51285				3.3	14c	210	15d					
DINITROTOLUENE, 2,4-	121142				0.66	14c	28.5	15d				5.1E-03	13
DIOXIN	1746016				1.0E-06	19	1E-05	19				7.4E-10	29
ENDOSULFAN	115297				0.00938	14b	0.12	15c				1.0E-05	13
ENDRIN	72208				0.00402	14b	5	14e				2.0E-07	29
ETHYLBENZENE	100414			10	0.005	14a	0.3	14g	2000	2.3	13	10	29
ETHYLENE DIBROMIDE	106934				0.005	14a	0.3	14g	200000	26	24	12	29
FLUORANTHENE	206440	0.5			0.66	14c	11	15d				5.0E-06	13
FLUORENE	86737	0.5			0.66	14c	1	14e					
HEPTACHLOR	76448				0.00201	14b	1	14e	300	0.02	13	3.0E-04	29
HEPTACHLOR EPOXIDE	1024573				0.05561	14b	1.5	14e	300	0.019	13	2.6E-06	13
HEXACHLOROBENZENE	118741				0.66	14c	1	14e				1.09E-05	13
HEXACHLOROBUTADIENE	87683				0.66	14c	0.55	14g	12000		13	0.15	29
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)	58899				0.00268	14b	0.5	14e				9.4E-06	29
HEXACHLOROETHANE	67721				0.66	14b	8	15d				0.4	29
INDENO(1,2,3-cd)PYRENE	193395	0.5			0.66	14c	0.5	14e				1.0E-09	13
LEAD	7439921	69	8.8		8.4	14d	1	15b					
MERCURY	7439976	1	0.95		0.1	14i	0.2	14i				1.2E-03	29
METHOXYCHLOR	72435				0.11792	14b	1.5	14e				1.4E-06	13
METHYL ETHYL KETONE	78933			42	0.1	14a	100	14a	32000	11	24	100	29
METHYL ISOBUTYL KETONE	108101			2	0.05	14a	50	14a	9700	0.1	25	10	29
METHYL MERCURY	22967926												
METHYL TERT BUTYL ETHER	1634044				0.05	14f	0.5	14f				245	29
METHYLENE CHLORIDE	75092			600	0.005	14a	5	14f	540000	160	13	429	29
METHYLNAPHTHALENE, 2-	91576	0.5			0.66	14c	10	14c	68		28		
NAPHTHALENE	91203	0.5		5	0.66	14c	0.2	14g	440	0.084	13	8.2E-02	29
NICKEL	7440020	30			3	14d	15	15b					
PENTACHLOROPHENOL	87865				3.3	14c	15	14e				1.1E-04	29
PHENANTHRENE	85018	0.5			0.66	14c	1	14e	55		24	9.6E-04	13
PHENOL	108952				0.66	14c	10	14c	156.8	0.04	13	0.35	29
POLYCHLORINATED BIPHENYLS (PCBs)	1336363				0.04355	14b	0.325	14b					
PYRENE	129000	0.5			0.66	14c	0.5	14e				2.5E-06	13
SELENIUM	7782492				15	14d	75	15b					
SILVER	7440224		4.7		1.4	14d	7	15b					
STYRENE	100425			5	0.005	14a	0.3	14g	1360	0.3	13	5	29
TETRACHLOROETHANE, 1,1,1,2-	630206				0.005	14a	5	14a				10	29
TETRACHLOROETHANE, 1,1,2,2-	79345			0.01	0.005	14a	2	14f	10470	1.5	13	4	29
TETRACHLOROETHYLENE	127184			11	0.005	14a	1.5	14f	31730	4.68	13	19	29
THALLIUM	7440280				8	14d	40	15b					
TOLUENE	108883			29	0.005	14a	0.5	14f	30000	8	13	28	29
TOTAL PETROLEUM HYDROCARBONS	NA												
TRICHLOROBENZENE, 1,2,4-	120821			0.04	0.66	14c	1	14g	22000	2.96	27		
TRICHLOROETHANE, 1,1,1-	71556			30	0.005	14a	1.5	14f	65127	120	13	100	29

------------------ file: TXINF3-1.wk1, 4/20/94------------------

Table 3.1, continued...

TABLE 3-1

PQLs, BACKGROUND, SOLUBILITY, ODOR DATA & OTHER PHYSICAL CONSTANTS

OIL AND/OR HAZARDOUS MATERIAL	CAS NUMBER	SOIL BACK-GROUND mg/kg	GROUND WATER BACK-GROUND ug/L	INDOOR AIR BACK-GROUND ug/cu m	SOIL PQL mg/kg	REF	WATER PQL ug/L	REF	ODOR THRESHOLD ug/m3	ODOR THRESHOLD ppm	REF	VAPOR PRESSURE (Torr@20-30C)	REF
TRICHLOROETHANE, 1,1,2-	79005			30	0.005	14a	0.5	14g				25	29
TRICHLOROETHYLENE	79016			5	0.005	14a	2	14f	1360000		28	77	29
TRICHLOROPHENOL, 2,4,5-	95954				0.66	14c	10	14c					
TRICHLOROPHENOL 2,4,6-	88062				0.66	14c	10	14c	0.3	2.6E-03	13		
VINYL CHLORIDE	75014				0.01	14a	1.5	14f	771244	3000	13	2580	29
XYLENES (Mixed Isomers)	1330207			3	0.005	14a	2.5	14f	441	0.1	13	6	29
ZINC	7440666	110			0.4	14d	2	15b					

file: TXINF3-1.wk1, 4/20/94

TABLE 3-1

PQLs, BACKGROUND, SOLUBILITY, ODOR DATA & OTHER PHYSICAL CONSTANTS OIL AND/OR HAZARDOUS MATERIAL	ODOR INDEX	SOLUBILITY ug/L	REF	HENRY'S LAW CONSTANT atm-m3/mol	REF	Log Kow	REF	Koc ml/g	REF	MOLECULAR WEIGHT g/mole	REF
ACENAPHTHENE		3.42E+03	29	2.41E-04	29	3.98	13	4.6E+03	13	154	13
ACENAPHTHYLENE		3.93E+03	13	1.45E-03	13	4.07	13	2.5E+03	13	154	13
ACETONE	20.77	1.00E+09	11	4.26E-05	13	-0.24	13	5.4E+00	13	58	13
ALDRIN	5.87E-06	1.70E+01	29	4.96E-04	29	3.01	13	4.9E+04	13	365	13
ANTHRACENE		1.29E+03	29	8.60E-05	29	4.45	13	1.4E+04	13	178	13
ANTIMONY		-		-	-	-	-	-	-	122	13
ARSENIC		-		-	-	-	-	-	-	75	13
BENZENE	63.33	1.78E+06	SES	5.50E-03	SES	2.13	13	8.3E+01	SES	78	13
BENZO(a)ANTHRACENE		1.00E+01	29	1.00E-06	13	5.61	13	2.0E+05	13	228	13
BENZO(a)PYRENE		3.80E+00	29	4.90E-07	29	6.06	13	5.5E+06	13	252	13
BENZO(b)FLUORANTHENE		1.40E+01	11	1.22E-05	13	6.06	13	5.5E+05	13	252	13
BENZO(g,h,i)PERYLENE		2.60E-01	29	1.44E-07	13	6.51	13	1.6E+06	13	276	13
BENZO(k)FLUORANTHENE		8.00E-01	20	3.87E-05	13	6.06	13	5.5E+05	11	252	13
BERYLLIUM		-		-	-	-	-	-	-	9	13
BIPHENYL, 1,1-		7.50E+03	29	4.08E-04	29	-	-			154	11
BIS(2-CHLOROETHYL)ETHER	14.49	1.02E+07	29	1.30E-05	29	1.58	13	1.3E+01	13	143	13
BIS(2-CHLOROISOPROPYL)ETHER	2.66	1.70E+06	11	1.13E-04	11	2.1	11	6.1E+01	11	171	11
BIS(2-ETHYLHEXYL)PHTHALATE		1.30E+03	29	3.00E-07	29	5.11	13	1.0E+05	13	391	13
BROMODICHLOROMETHANE		4.50E+06	13	2.12E-03	29	2.1	13	6.3E+01	13	164	13
BROMOFORM	4.31	3.20E+06	29	5.32E-04	29	2.38	13	1.1E+02	13	253	13
BROMOMETHANE	71.00	1.75E+07	29	1.97E-01	13	1.1	13	5.9E+00	13	95	13
CADMIUM		-		-	-	-	-	-	-	112	13
CARBON TETRACHLORIDE	11.30	8.00E+05	29	2.93E-02	29	2.64	13	1.1E+02	13	154	13
CHLORDANE	7.12E-05	5.60E+01	29	4.79E-05	29	5.54	13	4.4E+04	13	410	13
CHLOROANILINE, p-		2.60E+06	20	3.31E-07	20	1.83	20	6.4E+01	calc	128	20
CHLOROBENZENE	53.64	4.88E+05	29	3.93E-03	29	2.84	13	3.3E+02	13	113	13
CHLOROFORM	1.88	9.30E+06	29	3.39E-03	29	1.97	13	3.1E+01	11	119	13
CHLOROPHENOL, 2-		2.85E+07	29	1.03E-05	29	2.15	12	1.1E+02	calc	129	20
CHROMIUM(III)		-		-	-	-	-	-	-	52	13
CHROMIUM(VI)		-		-	-	-	-	-	-	52	13
CHRYSENE		6.00E+00	29	1.05E-06	29	5.61	13	2.0E+05	13	228	13
CYANIDE	1068.97	1.00E+09	11	1.90E+03	20	0.66	13	9.2E+00	calc	27	13
DIBENZO(a,h)ANTHRACENE		5.00E-01	29	7.30E-08	29	6.84	13	3.3E+06	13	278	13
DIBROMOCHLOROMETHANE		4.00E+06	13	7.83E-04	29	2.24	13	8.3E+01	13	208	13
DICHLOROBENZENE, 1,2- (o-DCB)	0.03	1.45E+05	29	1.94E-03	29	3.38	12	1.7E+03	11	147	11
DICHLOROBENZENE, 1,3- (m-DCB)		1.23E+05	29	2.63E-03	29	3.6	12	1.7E+03	11	147	11
DICHLOROBENZENE, 1,4- (p-DCB)	10.00	7.90E+04	29	2.72E-03	29	3.52	13	1.8E+03	13	147	13
DICHLOROBENZIDINE, 3,3'-		3.10E+03	29	8.33E-07	11	3.51	12	1.6E+03	11	253	11
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)		1.60E+02	29	7.96E-06	11	6.2	13	7.8E+05	13	320	13
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)		4.00E+01	29	6.80E-05	13	7	13	4.4E+06	13	318	13
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)		3.10E+00	29	3.89E-05	29	6.19	13	2.4E+05	13	354	13
DICHLOROETHANE, 1,1-	0.47	5.50E+06	29	5.45E-03	29	1.79	13	5.8E+01	13	99	13
DICHLOROETHANE, 1,2-	13.17	8.69E+06	29	1.10E-03	29	1.48	13	1.4E+01	13	99	13
DICHLOROETHYLENE, 1,1-	1.18	2.10E+05	29	1.49E-02	29	2.13	13	6.5E+01	13	97	13
DICHLOROETHYLENE, CIS-1,2-		8.00E+05	29	4.08E-03	29	1.86	13	4.9E+01	13	97	13
DICHLOROETHYLENE, TRANS-1,2-	19.47	6.00E+05	29	5.32E-03	29	2.09	13	4.9E+01	13	97	13
DICHLOROPHENOL, 2,4-	0.32	4.50E+06	29	2.80E-06	29	2.92	13	6.0E+03	13	163	13
DICHLOROPROPANE, 1,2-	168.00	2.70E+06	29	2.82E-03	29	1.99	13	4.7E+01	13	113	13

------------------ file: TXINF3-1.wk1, 4/20/94------------------

Table 3.1, continued...

TABLE 3-1

PQLs, BACKGROUND, SOLUBILITY, ODOR DATA & OTHER PHYSICAL CONSTANTS

OIL AND/OR HAZARDOUS MATERIAL	ODOR INDEX	SOLUBILITY ug/L	REF	HENRY'S LAW CONSTANT atm-m3/mol	REF	Log Kow	REF	Koc ml/g	REF	MOLECULAR WEIGHT g/mole	REF
DICHLOROPROPENE, 1,3-	43.00	2.70E+06	29	3.50E-03	29	1.6	13	2.6E+01	13	111	13
DIELDRIN		1.86E+02	29	5.84E-05	29	4.55	13	7.4E+03	13	381	29
DIETHYL PHTHALATE		8.96E+05	11	1.14E-06	11	2.47	12	1.4E+02	11	222	11
DIMETHYL PHTHALATE		5.00E+06	29	1.05E-07	20	1.56	12	1.4E+02	calc	194	29
DIMETHYLPHENOL, 2,4-		7.87E+06	20	1.70E-05	29	2.3	12	4.0E+01	calc	122	29
DINITROPHENOL, 2,4-		5.60E+06	29	6.45E-10	29	1.54	12	1.7E+01	11	184	11
DINITROTOLUENE, 2,4-		2.70E+05	29	4.50E-06	13	2	13	4.5E+01	13	182	13
DIOXIN		1.93E-02	29	2.10E-03	29	6.8	12	3.3E+06	11	322	11
ENDOSULFAN		1.50E+02	13	1.00E-05	13	3.62	13	3.2E+03	13	407	13
ENDRIN		2.60E+02	29	4.00E-07	29	5.338	13	1.7E+03	13	381	13
ETHYLBENZENE	4.35	1.61E+05	SES	3.43E-03	SES	3.13	13	5.7E+02	SES	106	13
ETHYLENE DIBROMIDE	0.46	4.30E+06	29	6.73E-04	11	1.96	13	4.4E+01	11	188	11
FLUORANTHENE		2.65E+02	29	6.50E-06	29	4.9	13	3.8E+04	13	202	13
FLUORENE		1.90E+03	29	1.17E-04	29	4.18	13	7.3E+03	13	166	13
HEPTACHLOR	0.01	5.60E+01	29	1.48E-03	29	5.44	13	2.2E+04	13	374	13
HEPTACHLOR EPOXIDE	1.37E-04	3.50E+02	29	3.16E-05	29	5.4	13	2.3E+04	13	389	13
HEXACHLOROBENZENE		1.10E+02	29	1.70E-03	29	6.18	13	1.2E+06	13	285	13
HEXACHLOROBUTADIENE	1.17E-03	2.00E+03	29	2.56E-02	29	4.78	12	2.9E+04	11	261	11
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)		7.00E+03	29	4.93E-07	29	3.61	13	3.7E+03	13	291	13
HEXACHLOROETHANE		5.00E+04	29	9.85E-03	29	3.93	12	2.0E+04	11	237	11
INDENO(1,2,3-cd)PYRENE		5.30E-01	11	6.95E-08	29	6.58	13	1.6E+06	13	276	13
LEAD		-		-	-	-	-	-	-	207	11
MERCURY		5.60E+01	29	-	29	-	-	-	-	201	13
METHOXYCHLOR		4.00E+01	29	1.60E-05	13	5.08	13	7.9E+04	13	346	13
METHYL ETHYL KETONE	9.09	2.75E+08	29	2.74E-05	11	0.29	13	3.5E+00	13	72	13
METHYL ISOBUTYL KETONE	100.00	1.91E+07	29	1.38E-04	20	1.19	20	3.1E+00	calc	100	11
METHYL MERCURY		-		-	-	-	-	-	-	231	29
METHYL TERT BUTYL ETHER		4.80E+07	29	5.91E-04	calc	1.05	21	2.7E+01	calc	88	29
METHYLENE CHLORIDE	2.68	1.67E+07	29	3.19E-03	29	1.3	13	8.8E+00	22	85	13
METHYLNAPHTHALENE, 2-		2.60E+04	29	2.90E-04	20	3.86	20	7.2E+02	calc	142	13
NAPHTHALENE	0.98	3.10E+04	SES	1.18E-03	SES	3.29	13	1.3E+03	SES	128	13
NICKEL		-		-	-	-	-	-	-	59	13
PENTACHLOROPHENOL		1.40E+04	29	2.80E-06	29	5.01	13	3.2E+04	13	266	13
PHENANTHRENE	2.4E-03	8.16E+02	29	3.93E-05	29	4.45	13	1.4E+04	13	178	13
PHENOL	8.75	8.00E+07	29	1.30E-06	29	1.46	13	9.1E+01	13	94	13
POLYCHLORINATED BIPHENYLS (PCBs)		5.90E+02	13	2.00E-03	13	6.5	13	5.3E+05	11	varies	
PYRENE		1.60E+02	29	5.10E-06	29	4.88	13	3.8E+04	13	202	13
SELENIUM		-		-	-	-	-	-	-	79	13
SILVER		-		-	-	-	-	-	-	108	13
STYRENE	16.67	3.00E+05	29	2.61E-03	13	2.95	13	3.1E+00	calc	104	13
TETRACHLOROETHANE, 1,1,1,2-		2.90E+06	29	1.10E-02	29	-	-	5.4E+01	11	168	11
TETRACHLOROETHANE, 1,1,2,2-	2.67	2.90E+06	29	3.80E-04	29	2.39	13	4.6E+01	13	168	13
TETRACHLOROETHYLENE	4.06	2.00E+05	SES	2.04E-03	SES	3.4	13	4.7E+02	SES	166	13
THALLIUM		-		-	-	-	-	-	-	204	13
TOLUENE	3.50	5.35E+05	SES	6.68E-03	SES	2.79	13	2.7E+02	SES	92	13
TOTAL PETROLEUM HYDROCARBONS		-				-	-			-	-
TRICHLOROBENZENE, 1,2,4-		1.90E+04	29	1.42E-03	29	3.98	12	9.2E+03	11	181	11
TRICHLOROETHANE, 1,1,1-	0.83	7.30E+05	SES	2.31E-02	SES	2.49	13	1.6E+02	SES	133	13

------------------ file: TXINF3-1.wk1, 4/20/94--

TABLE 3-1

PQLs, BACKGROUND, SOLUBILITY, ODOR DATA & OTHER PHYSICAL CONSTANTS OIL AND/OR HAZARDOUS MATERIAL	ODOR INDEX	SOLUBILITY ug/L	REF	HENRY'S LAW CONSTANT atm-m3/mol	REF	Log Kow	REF	Koc ml/g	REF	MOLECULAR WEIGHT g/mole	REF
TRICHLOROETHANE, 1,1,2-		4.50E+06	29	9.10E-04	13	2.42	13	3.1E+02	13	133	13
TRICHLOROETHYLENE	0.01	1.10E+06	SES	9.12E-03	SES	2.42	13	1.2E+02	SES	131	13
TRICHLOROPHENOL, 2,4,5-		1.19E+06	29	2.18E-04	11	3.72	11	8.9E+01	11	197	11
TRICHLOROPHENOL 2,4,6-		8.00E+05	29	4.00E-06	29	3.69	13	2.0E+03	13	197	13
VINYL CHLORIDE	0.86	1.10E+03	29	2.78E-02	29	1.36	13	9.8E+01	13	63	13
XYLENES (Mixed Isomers)	60.00	1.71E+05	SES	5.27E-03	SES	3.33	13	3.0E+02	SES	106	13
ZINC		-		-	-	-	-	-	-	65	13

Table 3.1, continued...

4.0 GROUNDWATER

MCP Numerical Standards have been developed for four categories of groundwater, as described in the following subsections. The four categories were developed to address 3 major pathways of exposure to human and environmental receptors (Categories GW-1, GW-2 and GW-3), plus an "Upper Concentration Limit" to protect against general degradation of the Commonwealth's groundwater resources.

> ***Note that no one groundwater category is consistently more stringent than another, and that more than one category may be applicable at a given site.***

The applicability of a particular groundwater category depends upon the current and foreseeable future use(s) of the groundwater, as determined by criteria in the regulations (310 CMR 40.0932).

4.1 CATEGORY GW-1: DRINKING WATER

MCP Category GW-1 Standards (310 CMR 40.0974(2)) apply to groundwater which is considered either a current or a future source of drinking water. The regulatory criteria used to determine the applicability the GW-1 standards are based upon an issues paper developed jointly be the MA DEP Bureau of Waste Site Cleanup and the Bureau of Resource Protection (MA DEP, 1992b).

Drinking water standards are the most common type of environmental standard, and there is an established methodology which can be used to develop criteria for additional chemicals. In order to build upon the existing body of drinking water standards and guidelines, the Bureau of Waste Site Cleanup has determined that:

- Existing drinking water standards promulgated in 310 CMR 22.000 have been adopted as MCP GW-1 standards. There are thirty-five (35) such standards on the MCP GW-1 list.
- Existing drinking water guidelines developed by the MA DEP Office of Research and Standards for the MA DEP Division of Water Supply have been adopted as MCP GW-1 standards. There are twenty-nine (29) such standards on the MCP GW-1 list.
- MCP GW-1 Standards for chemicals without existing drinking water standards or guidelines have been developed in a manner consistent with the U.S. EPA and MA DEP Division of Water Supply methodology.

4.1.1 General Methodology

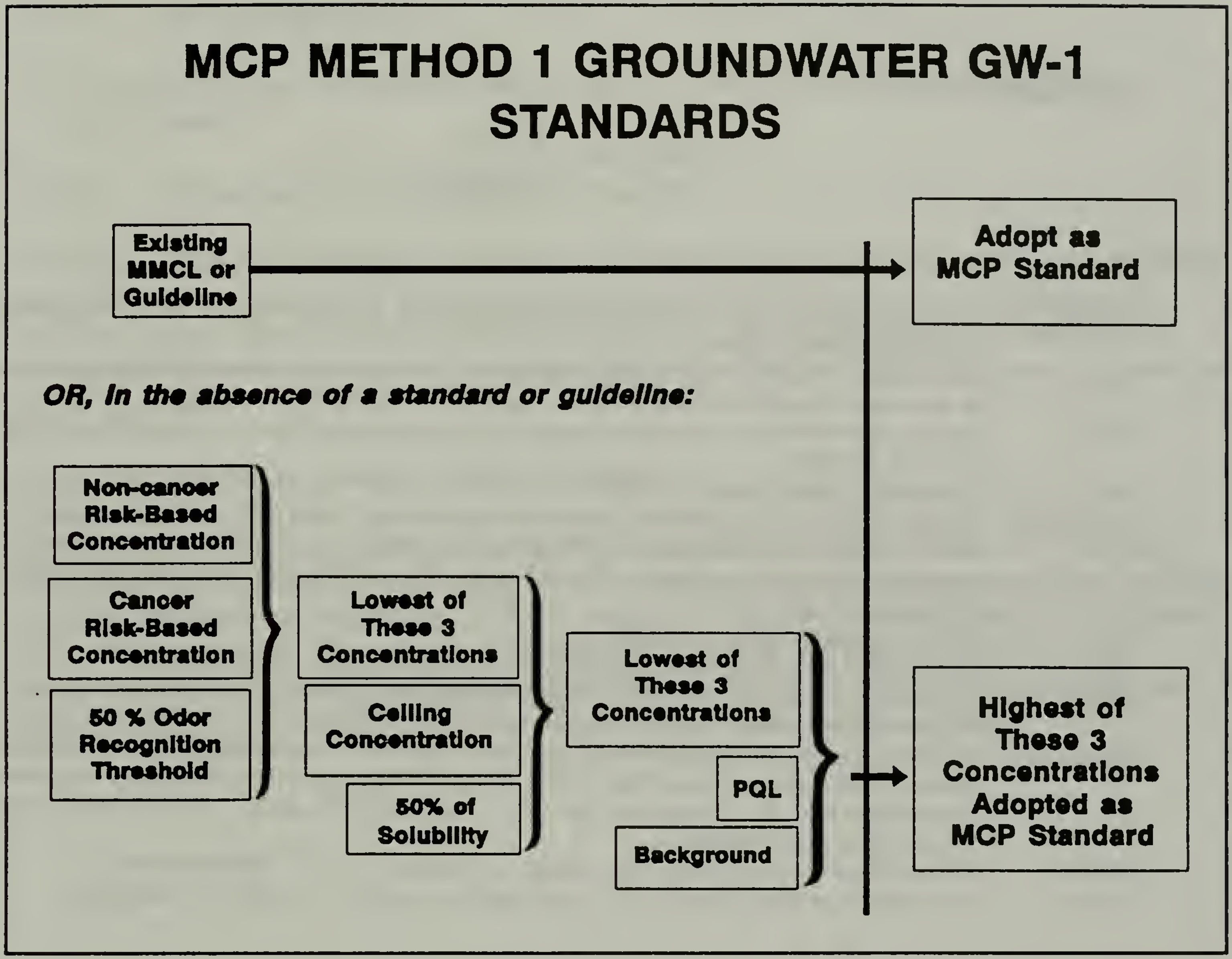
The sequential approach taken to the development of MCP GW-1 standards is as follows:

STEP	DESCRIPTION
1	Adopt an existing drinking water standard or guideline when one exists. If no such standard or guideline exists, follow steps 2 through 8.
2	Standard toxicity information and risk assessment, and odor threshold, if available, are used to identify risk/odor-based concentrations associated with (a) 20% of an allowable daily intake (based on non-cancer health effects), (b) an excess lifetime cancer risk equal to one-in-one million, or (c) a 50% odor recognition threshold. The lowest of these three values is carried through the process.
3	A value of ½ the solubility of the chemical is identified.
4	A ceiling concentration of 0.005% (50,000 $\mu g/l$) is noted.
5	The lowest of the three values identified in steps 2, 3, and 4 is identified and carried through the process.
6	A Practical Quantitation Limit (PQL) for an appropriately sensitive analytical method is identified.
7	A "background" concentration is identified, if available.
8	The highest of the three values, identified in steps 5, 6, and 7 is chosen. This value is adopted as the MCP GW-1 standard

This process is diagramed in Figure 4-1.

FIGURE 4-1

DERIVATION OF GW-1 STANDARDS



4.1.2. Risk Assessment Equations

The equation used to identify a non-cancer risk-based concentration in drinking water is given as:

$$[OHM]_{dw} = \frac{0.2 \, x \, RfD \, x \, BW \, x \, AP \, x \, C}{VI \, x \, RAF \, x \, F \, x \, D1 \, x \, D2} \qquad (2)$$

simplified to:

$$[OHM]_{dw} = \frac{7{,}000 \, x \, RfD}{RAF} \qquad (3)$$

The equation used to evaluate potential carcinogenic effects associated with exposure to contaminated drinking water is given as:

$$[OHM]_{dw} = \frac{ELCR \times BW \times AP \times C}{VI \times RAF \times F \times D1 \times D2 \times CSF} \tag{4}$$

simplified to:

$$[OHM]_{dw} = \frac{0.035}{CSF \times RAF} \tag{5}$$

Where:

$[OHM]_{dw}$ =	A risk-based (non-cancer or cancer risk) concentration, in drinking water, for the oil of hazardous material. In units: μg/liter.
0.2 =	A 20% Source Allocation Factor, used to insure that only 20% of an allowable daily intake of the oil or hazardous material may come from the ingestion of drinking water.
RfD =	The oral Reference Dose or substitute toxicity value identified for the oil or hazardous material. In units of: mg/kg/day.
BW =	The receptor's Body Weight: 70 kg.
D2 and AP =	The Duration (D2) of the exposure period and the Averaging Period (AP). For the purposes of setting a MCP GW-1 standard, the drinking water exposures are assumed to occur over the receptor's lifetime: D2 = 70 years, AP = 70 years. The quotient of these two terms is equal to 1 and is dimensionless.
C =	Units Conversion Factor: 10^3 μg/mg.
VI =	Daily volume of drinking water ingested by the receptor of concern: 2 liters/day.
RAF =	The Relative Absorption Factor for drinking water ingestion (A chemical- , route-, and health-endpoint- specific value). Dimensionless.
F and D1 =	The Frequency (F) of exposure and the Duration (D1) of each exposure event. The receptors are assumed to be exposed to the drinking water each and every day, and that exposure occurs over the course of the day. F = 1 event/day and D1 = 1 day/event. The product of these terms is equal to 1, and it is dimensionless.
ELCR =	Target Excess Lifetime Cancer Risk: one-in-one million, or 1×10^{-6} (dimensionless).
CSF =	The oral Cancer Slope Factor for the oil or hazardous material. In units of: $(mg/kg/day)^{-1}$

4.1.3 Exposure Parameters

The exposure parameters chosen to develop the risk-based concentration by the formulae described above have been chosen to be consistent with the standardized methodology used by the U.S. Environmental Protection Agency and the MA DEP Division of Water Supply to set drinking water standards.

4.1.3.1. Water Volume Ingested, VI

The drinking water consumption rates of 2 liters/day for lifetime exposures is a standard assumption described by the U.S. Environmental Protection Agency (U.S. EPA 1989b & 1991). An individual's water intake may vary by age, sex, geography or level of activity. Estimates of mean tap water consumption rates for adults (of various ages) fall in the range of approximately 0.6 to 1.6 liters/day. Estimates of mean intakes for young children fall in the range of approximately 0.2 to 0.5 liters/day (Ershow and Cantor, 1989). The ratio of drinking water

intake to body weight does not vary dramatically across age groups, however, as water intake increases as age (and thus body weight) increases.

4.1.3.2 Body Weight, BW

The assumption of an average body weight equal to 70 kg is the standard value (USEPA, 1989b).

4.1.3.3 Duration of the Exposure Period, D2

A lifetime of water consumption is assumed in developing the risk-based concentration. While a receptor may not occupy the same house throughout their lifetime, it is not unlikely that someone may be served by the same water source (e.g., the Massachusetts Water Resource Authority). In addition, a receptor may drink from the same source in the home, at school, and in the workplace.

4.1.4. Derivation of Category GW-1 Standards

The numerical derivation of the Category GW-1 Standards is given in Table 4.1. The table includes the noncancer and cancer risk-based concentrations, any existing standard or guideline, and the concentration adopted as the GW-1 standard. The last column indicates the ultimate basis of the standard. The references indicated in this table are presented at the end of Table 2.1. The standards specifically derived for the MCP (i.e., *not* those adopted from the MADEP Division of Water Supply) have been rounded to one significant figure.

TABLE 4.1

TABLE 4-1

GW-1 DERIVATION
310 CMR 40.0974(2)

OIL AND/OR HAZARDOUS MATERIAL	GW BACK-GROUND ug/L	WATER PQL ug/L	REF	ODOR THRESHOLD ug/L	REF	SOLU-BILITY ug/L	REF	Non-Cancer Risk-Based Concen. ug/L	Cancer Risk-Based Concen. ug/L	Existing Standard/ Guideline ug/L	Basis	Method 1 GROUNDWATER GW-1 STANDARD 310 CMR 40.0974(2) (Rounded) ug/L	BASIS
ACENAPHTHENE		10	14c	20	13	3.42E+03	29	4E+02				20	ODOR
ACENAPHTHYLENE		0.5	14e			3.93E+03	24	3E+02				300	Threshold
ACETONE		100	14a	20000	13	1.00E+09	11	7E+02		3000	ORSGL	3000	ORSGL
ALDRIN		0.5	14e	17	13	1.70E+01	29	2E-01	2E-03			0.5	PQL
ANTHRACENE		0.5	14e			1.29E+03	29	2E+03				600	Solubility
ANTIMONY		32	15b			-		3E+00		6	ORSGL	6	ORSGL
ARSENIC	5.5	50	17			-		2E+00	2E-02	50	MMCL	50	MMCL
BENZENE		0.5	14f	2000	13	1.78E+06	SES	4E+01	1E+00	5	MMCL	5	MMCL
BENZO(a)ANTHRACENE		1	14e			1.00E+01	29	3E+02	5E-03	0.2	ORSGL*	0.2	ORSGL*
BENZO(a)PYRENE		0.5	14e			3.80E+00	29	3E+02	5E-03	0.2	ORSGL	0.2	ORSGL
BENZO(b)FLUORANTHENE		1	14e			1.40E+01	13	3E+02	5E-03	0.2	ORSGL*	0.2	ORSGL*
BENZO(g,h,i)PERYLENE		0.5	14e			2.60E-01	29	3E+02				0.5	PQL
BENZO(k)FLUORANTHENE		1	14e			8.00E-01	30	3E+02	5E-03	0.2	ORSGL*	0.2	ORSGL*
BERYLLIUM		0.3	15b			-		4E+01	8E-03	4	ORSGL	4	ORSGL
BIPHENYL, 1,1-		0.1	14e			7.50E+03	29	4E+02				400	Threshold
BIS(2-CHLOROETHYL)ETHER		28.5	15d			1.02E+07	29		3E-02			30	PQL
BIS(2-CHLOROISOPROPYL)ETHER		28.5	15d	320	24	1.70E+06	24	3E+02	5E-01			30	PQL
BIS(2-ETHYLHEXYL)PHTHALATE		4	14e			1.30E+03	29	1E+02	2E+00	6	ORSGL	6	ORSGL
BROMODICHLOROMETHANE		2.5	14f			4.50E+06	13	1E+02	6E-01	5	ORSGL**	5	ORSGL**
BROMOFORM		3.5	14f	510	13	3.20E+06	29	1E+02	4E+00	5	ORSGL**	5	ORSGL**
BROMOMETHANE		0.55	14g			1.75E+07	29	1E+01		10	ORSGL	10	ORSGL
CADMIUM	4.2	4	15b			-		4E+00		5	MMCL	5	MMCL
CARBON TETRACHLORIDE		1.5	14f	520	13	8.00E+05	29	5E+00	3E-01	5	MMCL	5	MMCL
CHLORDANE		1.5	14e	2.5	24	5.60E+01	29	4E-01	3E-02	5	MMCL	5	MMCL
CHLOROANILINE, p-		20	14c			2.60E+06	30	3E+01				30	Threshold
CHLOROBENZENE		0.5	14f	50	13	4.88E+05	29	1E+02		100	MMCL	100	MMCL
CHLOROFORM		1	14f	2400	13	9.30E+06	29	7E+01	6E+00	5	ORSGL**	5	ORSGL**
CHLOROPHENOL, 2-		10	14c	0.18	24	2.85E+07	29	4E+01				10	PQL
CHROMIUM						-				100	MMCL	100	MMCL
CHROMIUM(III)		7	14d			-		7E+03		100	MMCL(TOTA	100	MMCL(TOTAL)
CHROMIUM(VI)		0.5	14h			-		4E+01		50	MMCL	50	MMCL
CHRYSENE		1.5	14e			6.00E+00	29	3E+02	5E-03	0.2	ORSGL*	0.2	ORSGL*
CYANIDE		0.1	15a	170	13	1.0E+09	11	1E+02		200	ORSGL	200	ORSGL
DIBENZO(a,h)ANTHRACENE		0.5	14e			5.00E-01	29	3E+02	5E-03	0.2	ORSGL*	0.2	ORSGL*
DIBROMOCHLOROMETHANE		2	14f			4.00E+06	13	1E+02	4E-01	5	ORSGL**	5	ORSGL**
DICHLOROBENZENE, 1,2- (o-DCB)		5	14f	10	24	1.45E+05	29	6E+02		600	MMCL	600	MMCL
DICHLOROBENZENE, 1,3- (m-DCB)		0.6	14g			1.23E+05	29	6E+02				600	Threshold
DICHLOROBENZENE, 1,4- (p-DCB)		0.2	14g	11	13	7.90E+04	29		1E+00	5	MMCL	5	MMCL
DICHLOROBENZIDINE, 3,3'-		82.5	15d			3.10E+03	29		8E-02			80	PQL
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)		0.012	15c			1.60E+02	29		1E-01			0.1	Cancer
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)		0.05	15c			4.00E+01	29		1E-01			0.1	Cancer
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)		0.3	15c	350	13	3.10E+00	29	4E+00	1E-01			0.3	PQL
DICHLOROETHANE, 1,1-		1	14f			5.50E+06	29	5E+02		70	ORSGL	70	ORSGL
DICHLOROETHANE, 1,2-		1	14f	20000	13	8.69E+06	29	1E+02	4E-01	5	MMCL	5	MMCL
DICHLOROETHYLENE, 1,1-		1	14f			2.10E+05	29	6E+01	6E-02	7	MMCL	7	MMCL
DICHLOROETHYLENE, CIS-1,2-		0.6	14g			8.00E+05	29	7E+01		70	MMCL	70	MMCL
DICHLOROETHYLENE, TRANS-1,2-		0.3	14g	260	13	6.00E+05	29	1E+02		100	MMCL	100	MMCL
DICHLOROPHENOL, 2,4-		13.5	15d	0.3	13	4.50E+06	29	2E+01				10	PQL

------------ file: TXINF4-1.wk1, 4/20/94 ------------

TABLE 4-1

GW-1 DERIVATION
310 CMR 40.0974(2)

OIL AND/OR HAZARDOUS MATERIAL	GW BACK-GROUND ug/L	WATER PQL ug/L	REF	ODOR THRESHOLD ug/L	REF	SOLU-BILITY ug/L	REF	Non-Cancer Risk-Based Concen. ug/L	Cancer Risk-Based Concen. ug/L	Existing Standard/ Guideline ug/L	Basis	Method 1 GROUNDWATER GW-1 STANDARD 310 CMR 40.0974(2) (Rounded) ug/L	BASIS
DICHLOROPROPANE, 1,2-		1	14f	10	13	2.70E+06	29		5E-01	5	MMCL	5	MMCL
DICHLOROPROPENE, 1,3-		5	14a			2.70E+06	29	2E+00	2E-01	0.5	ORSGL	0.5	ORSGL
DIELDRIN		0.1	15c	41	13	1.86E+02	29	4E-01	2E-03			0.1	PQL
DIETHYL PHTHALATE		4	14e			8.96E+05	11	6E+03				6000	Threshold
DIMETHYL PHTHALATE		1.5	14e			5.00E+06	29	7E+04				50000	Ceiling
DIMETHYLPHENOL, 2,4-		13.5	15d	400	24	7.87E+06	30	1E+02				100	Threshold
DINITROPHENOL, 2,4-		210	15d			5.60E+06	29	1E+01				200	PQL
DINITROTOLUENE, 2,4-		28.5	15d			2.70E+05	29	1E+01	5E-02			30	PQL
DIOXIN		1E-05	19			1.93E-02	29		2E-07	3E-05	ORSGL	3E-05	ORSGL
ENDOSULFAN		0.12	15c			1.50E+02	13	4E-01				0.4	Threshold
ENDRIN		5	14e	41	13	2.60E+02	29	2E+00		2	MMCL	2	MMCL
ETHYLBENZENE		0.3	14g	29	13	1.61E+05	SES	7E+02		700	MMCL	700	MMCL
ETHYLENE DIBROMIDE		0.3	14g			4.30E+06	29	1E-01	4E-04	0.02	MMCL	0.02	MMCL
FLUORANTHENE		11	15d			2.65E+02	29	3E+02				100	Solubility
FLUORENE		1	14e			1.90E+03	29	3E+02				300	Threshold
HEPTACHLOR		1	14e	20	13	5.60E+01	29	4E+00	8E-03	0.4	MMCL	0.4	MMCL
HEPTACHLOR EPOXIDE		1.5	14e			3.50E+02	29	9E-02	4E-03	0.2	MMCL	0.2	MMCL
HEXACHLOROBENZENE		1	14e	3000	24	1.10E+02	29	6E+00	2E-02	1	ORSGL	1	ORSGL
HEXACHLOROBUTADIENE		0.55	14g	6	24	2.00E+03	29	1E+01	4E-01			0.6	PQL
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)		0.5	14e	12000	13	7.00E+03	29	2E+00	3E-02	0.2	MMCL	0.2	MMCL
HEXACHLOROETHANE		8	15d	10	24	5.00E+04	29	7E+00	2E+00			8	PQL
INDENO(1,2,3-cd)PYRENE		0.5	14e			5.30E-01	11	3E+02	5E-03	0.2	ORSGL*	0.2	ORSGL*
LEAD	8.8	1	15b			-		1E+01		15	AL-MCL	15	AL-MCL
MERCURY	0.95	0.2	14i			5.60E+01	29	2E+00		2	MMCL	2	MMCL
METHOXYCHLOR		1.5	14e	4700	13	4.00E+01	29	4E+01		40	MMCL	40	MMCL
METHYL ETHYL KETONE		100	14a	1000	24	2.75E+08	29	4E+03		350	ORSGL	350	ORSGL
METHYL ISOBUTYL KETONE		50	14a			1.91E+07	29	4E+02		350	ORSGL	350	ORSGL
METHYL MERCURY						-		2E+00				2	Threshold
METHYL TERT BUTYL ETHER		0.5	14f			4.80E+07	29	7E+02		700	ORSGL	700	ORSGL
METHYLENE CHLORIDE		5	14f	9100	13	1.67E+07	29	4E+02	5E+00	5	ORSGL	5	ORSGL
METHYLNAPHTHALENE, 2-		10	14c	10	13	2.60E+04	29	3E+02				10	ODOR
NAPHTHALENE		0.2	14g	21	13	3.10E+04	SES	3E+02				20	ODOR
NICKEL		15	15b			-		1E+02		100	ORSGL	100	ORSGL
PENTACHLOROPHENOL		15	14e	587	13	1.40E+04	29	2E+02	3E-01	1	MMCL	1	MMCL
PHENANTHRENE		1	14e	1000	24	8.16E+02	29	3E+02				300	Threshold
PHENOL		10	14c	7900	13	8.00E+07	29	4E+03				4000	Threshold
POLYCHLORINATED BIPHENYLS		0.325	14b			3.10E+01	11	1E-01	5E-03	0.5	MMCL	0.5	MMCL
PYRENE		0.5	14e			1.60E+02	29	2E+02				80	Solubility
SELENIUM		75	15b			-		4E+01		50	MMCL	50	MMCL
SILVER	4.7	7	15b			-		4E+01				40	Threshold
STYRENE		0.3	14g	11	13	3.00E+05	29	1E+03	1E+00	100	MMCL	100	MMCL
TETRACHLOROETHANE, 1,1,1,2-		5	14a			2.00E+05	29	2E+02	1E+00			5	PQL
TETRACHLOROETHANE, 1,1,2,2-		2	14f	500	13	2.90E+06	29		2E-01			2	PQL
TETRACHLOROETHYLENE		1.5	14f	300	13	2.00E+05	SES	7E+01	7E+00	5	MMCL	5	MMCL
THALLIUM		40	15b			-		5E-01		2	ORSGL	2	ORSGL
TOLUENE		0.5	14f	40	13	5.35E+05	SES	1E+03		1000	MMCL	1000	MMCL
TOTAL PETROLEUM HYDROCARBONS												1000	Default
TRICHLOROBENZENE, 1,2,4-		1	14g			1.90E+04	29	7E+01		70	ORSGL	70	ORSGL

------------ file: TXINF4-1.wk1, 4/20/94 ------------

Table 4.1, continued...

TABLE 4-1

GW-1 DERIVATION
310 CMR 40.0974(2)

OIL AND/OR HAZARDOUS MATERIAL	GW BACK-GROUND ug/L	WATER PQL ug/L	REF	ODOR THRESHOLD ug/L	REF	SOLU-BILITY ug/L	REF	Non-Cancer Risk-Based Concen. ug/L	Cancer Risk-Based Concen. ug/L	Existing Standard/ Guideline ug/L	Basis	Method 1 GROUNDWATER GW-1 STANDARD 310 CMR 40.0974(2) (Rounded) ug/L	BASIS
TRICHLOROETHANE, 1,1,1-		1.5	14f	50000	24	7.30E+05	SES	6E+02		200	MMCL	200	MMCL
TRICHLOROETHANE, 1,1,2-		0.5	14g			4.50E+06	29	3E+01	6E-01	5	ORSGL	5	ORSGL
TRICHLOROETHYLENE		2	14f	10000	24	1.10E+06	SES	1E+01	3E+00	5	MMCL	5	MMCL
TRICHLOROPHENOL, 2,4,5-		10	14c	200	24	1.19E+06	29	7E+02				200	ODOR
TRICHLOROPHENOL 2,4,6-		10	14c	100	13	8.00E+05	29		3E+00			10	PQL
VINYL CHLORIDE		1.5	14f	3400	13	1.10E+03	29	7E+00	1E-02	2	MMCL	2	MMCL
XYLENES		2.5	14f	530	24	1.71E+05	SES	1E+04		10000	MMCL	10000	MMCL
ZINC		2	15b			-		2E+03				2000	Threshold

4.2 CATEGORY GW - 2: VOLATILIZATION

MCP Category GW-2 Standards (310 CMR 40.0974(2)) apply to groundwater which is considered both shallow and where there is currently (or there may in the future be) a structure built on the land above the groundwater. These standards are intended to address the potential migration of volatile oil or hazardous material from the groundwater into the indoor air, and are calculated for oil or hazardous materials exhibiting a vapor pressure equal to or greater than 0.01 Torr (measured at 20° to 30° C) where there is sufficient toxicological information available.

4.2.1 General Methodology

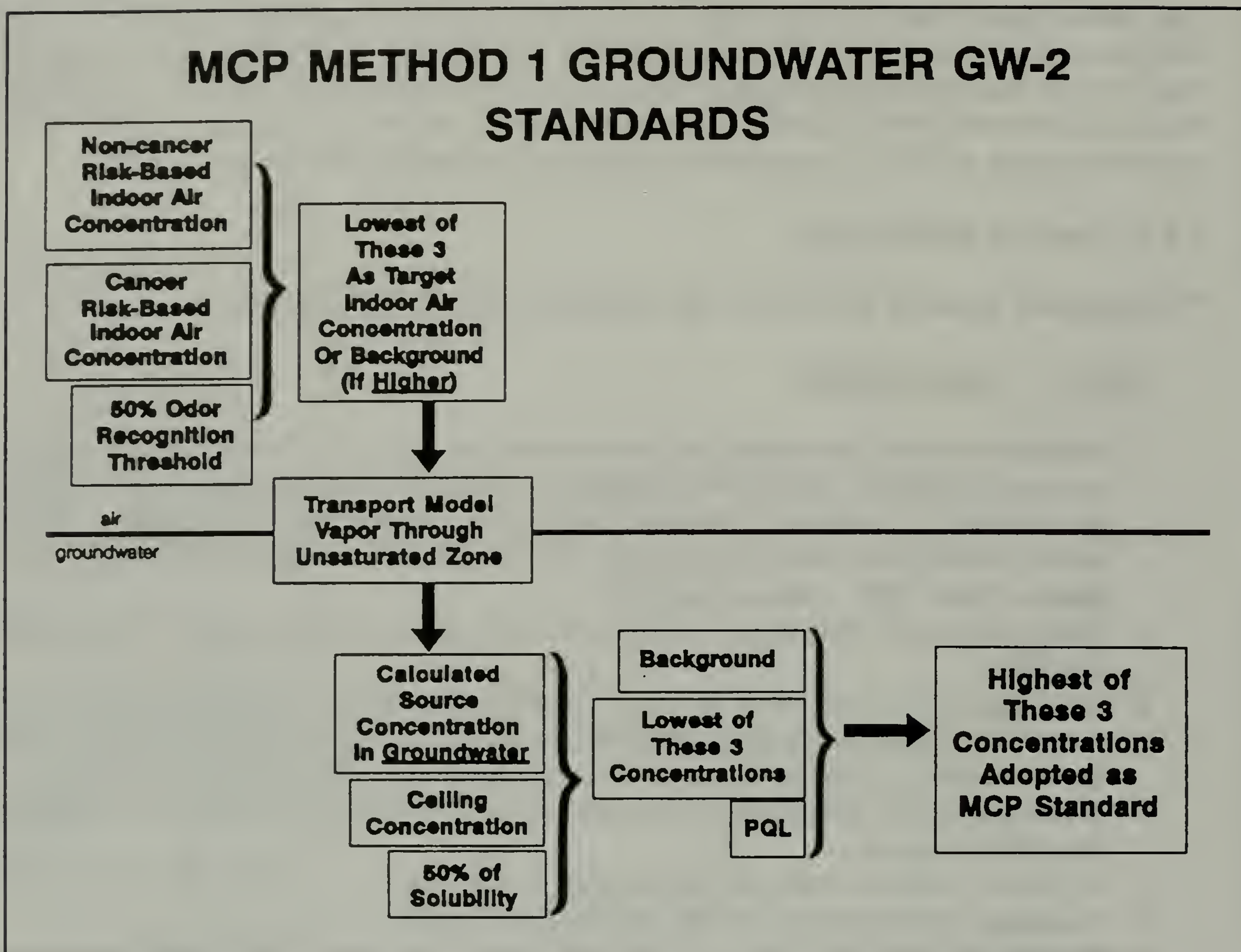
The sequential approach taken to the development of MCP GW-2 standards is:

STEP	DESCRIPTION
1	Standard toxicity information and risk assessment, and odor threshold, when available, are used to identify risk/odor-based indoor air concentrations associated with (a) 20% of an allowable daily exposure (based on non-cancer health effects), (b) an excess lifetime cancer risk equal to one-in-one million, or (c) a 50% odor recognition threshold. The lower of these three values is identified.
2	When the data is available, a background concentration of the chemical in indoor air is identified.
3	The higher of the two values identified in steps 1 and 2 is carried through the process.
4	A model is employed which considers the potential for the chemical to volatilize from the groundwater and migrate through the unsaturated zone. The model results in the identification of a groundwater concentration associated with the indoor air concentration identified in step 3.
5	A value of ½ the solubility of the chemical is identified.
6	A ceiling concentration of 0.005% (50,000 μg/l) is noted.
7	The lowest of the three values identified in steps 4, 5 and 6 is identified and carried through the process.
8	Practical Quantitation Limit (PQL) for an appropriately sensitive analytical method is identified.
9	A background concentration in groundwater is identified, if available.
10	The highest of the three values identified in steps 7, 8 and 9 is chosen. This value is adopted as the MCP GW-2 standard.

This process is diagramed in Figure 4-2.

FIGURE 4-2

DERIVATION OF GW-2 STANDARDS



4.2.2. Discussion

The volatilization of oil or hazardous material from contaminated groundwater and its infiltration to indoor air has proven to be a significant exposure pathway at some c.21E sites. Historically the transport of radon gas into indoor air has received a great deal of attention, but it is only recently that this migration pathway has been examined for the common volatile organic contaminants. Recent journal articles (Johnson and Ettinger, 1991; Little et al., 1992) provide discussions of this pathway and develop predictive models for its assessment.

The indoor air concentrations which result from the migration of these materials from the groundwater depend upon a large number of factors, including:

- depth to groundwater
- concentration of the material in groundwater
- partition coefficients
- groundwater flow
- building structure
- building ventilation rate

The model used to develop the MCP GW-2 standards adopts an attenuation factor (α = 5 x 10^{-4}) identified from Johnson and Ettinger (1991) for highly permeable soils (fine to medium sand, 10^{-7} cm^2). In such permeable soil, Johnson and Ettinger demonstrate that the attenuation coefficient is only weakly dependent on the structure of the foundation, which simplifies the methodology. The attenuation factor relates the indoor air concentration (C_I) to the soil-gas concentration at the surface of the groundwater (C_{sg}): $\alpha = C_I/C_{sg}$. The value of 5 x 10^{-4} used here is consistent with reported attenuation coefficients for radon of 16 x 10^{-4} (Little, et al., 1992).

4.2.3. Risk Assessment Equations

In the derivation of the GW-2 Standards, it is assumed that the receptors of concern are continually exposed to the indoor air under study. Site and Use specific information may be used to justify different exposure conditions in a Method 2 or Method 3 risk characterization.

The equation used to identify a non-cancer risk-based concentration in indoor air is given as:

$$[OHM]_{air} = 0.2\,x\,RfC \qquad (6)$$

The equation used to evaluate potential carcinogenic effects associated with exposure to contaminated indoor air is given as:

$$[OHM]_{air} = \frac{10^{-6}}{UR_{air}} \qquad (7)$$

Where:

$[OHM]_{air}$ =	A risk-based (non-cancer or cancer risk) concentration, in indoor air, for the oil of hazardous material. In units: $\mu g/m^3$.
0.2 =	A 20% Source Allocation Factor, used to insure that only 20% of an allowable daily exposure of the oil or hazardous material may come from the inhalation pathway.
RfC =	The inhalation Reference Concentration or substitute toxicity value identified for the oil or hazardous material. In units of: $\mu g/m^3$.
10^{-6} =	Target Excess Lifetime Cancer Risk of one-in-one million (dimensionless).
UR_{air} =	The inhalation Unit Risk for the oil or hazardous material. In units of: $(\mu g/m^3)^{-1}$

4.2.4 Transport Model Equation

The equation used to estimate allowable groundwater concentrations based upon potential indoor air exposure is given as:

$$[OHM]_{gw} = \frac{[OHM]_{air}}{\alpha \, x \, d \, x \, H \, x \, C} \tag{8}$$

Where:

$[OHM]_{air}$ =	The target indoor air concentration, in units of: $\mu g/m^3$
$[OHM]_{gw}$ =	The calculated groundwater concentration of the oil or hazardous material which would not result in an indoor air concentration greater than $[OHM]_{air}$. In units of μg/liter
α =	A calculated attenuation factor which relates the indoor air concentration to the concentration in the soil gas directly above the groundwater source: 5×10^{-4}. Dimensionless.
d =	A modification factor to convert theoretical groundwater:soil gas equilibrium concentrations to realistic environmental concentrations. This MADEP value is based upon observations and the professional judgement of MADEP staff. Dimensionless.
H =	Henry's Law Constant, dimensionless form.
C =	Units Conversion Factor, 1000 liter/m^3.

4.2.5. Derivation of Category GW-2 Standards

The derivation of the Category GW-2 Standards is given in Table 4.2. The table includes the noncancer and cancer risk-based indoor air concentrations, a preliminary concentration in groundwater, and the final concentration adopted as the GW-2 standard. The last column indicates the ultimate basis of the standard.

4.3 CATEGORY GW - 3: ENVIRONMENTAL CONCERNS

MCP Category GW-3 Standards (310 CMR 40.0974(2)) apply in all groundwater areas for a Method 1 risk characterization. These standards are intended to provide some protection against the migration and eventual discharge of groundwater contaminants to surface water at concentrations above an Ambient Water Quality Criterion. A dilution/attenuation factor of 10 is applied to allowable surface water concentrations to identify allowable groundwater concentrations.

For each oil or hazardous material the list of U.S. EPA Ambient Water Quality Criteria was examined, and the lowest environmentally-based (from among the Fresh Water Acute, Fresh Water Chronic, Marine Acute, and Marine Chronic) criterion was chosen and modified as described below.

> NOTE:
>
> Actual contamination in surface water may preclude the use of Method 1 to characterize risk (310 CMR 40.0942(1)(b)).

TABLE 4.2

Development of GW-2 Standards

TABLE 4-2

GW-2 DERIVATION 310 CMR 40.0974(2) OIL AND/OR HAZARDOUS MATERIAL	20% RfC ug/cu m	1E-06 ELCR LEVEL ug/cu m	INDOOR AIR BACK-GROUND ug/cu m (VAPORS)	ODOR THRESHOLD ug/cu m	REF	WATER PQL ug/L	REF	SOLUBILITY ug/L	REF	Atten-uation Factor (alpha)	Source Dilution Factor (d)	HENRY'S LAW CONSTANT conc/conc	Units Conver-sion l/cu m	Existing Standard ug/L	Basis	Volatility Based Value ug/L	Method 1 GROUNDWATER GW-2 STANDARD 310 CMR 40.0974(2) (Rounded) ug/L	Basis
ACETONE	2E+02		6	30862	13	100	14a	1.00E+09	11	0.0005	0.1	2E-03	1000	3000	ORSGL	1835568	50000	Ceiling
ALDRIN		2.04E-04		263	28	0.5	14e	1.70E+01	29	0.0005	0.1	2E-02	1000	3000	ORSGL	0	0.5	PQL
BENZENE	2E+00	1.20E-01	21	4890	13	0.5	14f	1.78E+06	SES	0.0005	0.1	2E-01	1000	5	MMCL	1866	2000	Bckgrnd-Air
BIS(2-CHLOROETHYL)ETHER		3.03E-03		287	13	28.5	15d	1.02E+07	29	0.0005	0.1	5E-04	1000	3000	ORSGL	114	100	Risk
BIS(2-CHLOROISOPROPYL)ETHER		1.00E-01		2240	24	28.5	15d	1.70E+06	24	0.0005	0.1	5E-03	1000	3000	ORSGL	432	400	Risk
BIS(2-ETHYLHEXYL)PHTHALATE	1E+00	7.69E-01				4	14e	1.30E+03	29	0.0005	0.1	1E-05	1000	6	ORSGL	1253128	700	Solubility
BROMOFORM		9.09E-01		13450	13	3.5	14f	3.20E+06	29	0.0005	0.1	2E-02	1000	5	ORSGL**	835	800	Risk
BROMOMETHANE	1E+00			80000	13	0.55	14g	1.75E+07	29	0.0005	0.1	8E+00	1000	10	ORSGL	2	2	Risk
CARBON TETRACHLORIDE	9E+01	6.67E-02	1	63000	13	1.5	14f	8.00E+05	29	0.0005	0.1	1E+00	1000	5	MMCL	17	20	Bckgrnd-Air
CHLOROBENZENE	4E+00		10	1000	13	0.5	14f	4.88E+05	29	0.0005	0.1	2E-01	1000	100	MMCL	1244	1000	Bckgrnd-Air
CHLOROFORM	1E+02	4.35E-02	3	421600	13	1	14f	9.30E+06	29	0.0005	0.1	1E-01	1000	5	ORSGL**	432	400	Bckgrnd-Air
DICHLOROBENZENE, 1,2- (o-DCB)	4E+01		1	305000	24	5	14f	1.45E+05	29	0.0005	0.1	8E-02	1000	600	MMCL	10077	10000	Risk
DICHLOROBENZENE, 1,3- (m-DCB)																	10000	Risk (o-DCB
DICHLOROBENZENE, 1,4- (p-DCB)	2E+02		0.5	1100	13	0.2	14g	7.90E+04	29	0.0005	0.1	1E-01	1000	5	MMCL	28748	30000	Risk
DICHLOROETHANE, 1,1-	1E+02			125000	13	1	14f	5.50E+06	29	0.0005	0.1	2E-01	1000	70	ORSGL	8967	9000	Risk
DICHLOROETHANE, 1,2-	1E+01	3.85E-02		2424	13	1	14f	8.69E+06	29	0.0005	0.1	5E-02	1000	5	MMCL	17	20	Risk
DICHLOROETHYLENE, 1,1-	1E+00	2.00E-02		125000	13	1	14f	2.10E+05	29	0.0005	0.1	6E-01	1000	7	MMCL	1	1	PQL
DICHLOROPROPANE, 1,2-	8E-01	5.35E-02		1190.5	13	1	14f	2.70E+06	29	0.0005	0.1	1E-01	1000	5	MMCL	9	9	Risk
DICHLOROPROPENE, 1,3-	4E+00	2.70E-02		4610	13	5	14a	2.70E+06	29	0.0005	0.1	1E-01	1000	0.5	ORSGL	4	5	PQL
ETHYLBENZENE	2E+02		10	2000	13	0.3	14g	1.61E+05	SES	0.0005	0.1	1E-01	1000	700	MMCL	28497	30000	Risk
ETHYLENE DIBROMIDE	4E-02	4.55E-03		200000	24	0.3	14g	4.30E+06	29	0.0005	0.1	3E-02	1000	0.02	MMCL	3	3	Risk
HEXACHLOROBUTADIENE		4.55E-02		12000	13	0.55	14g	2.00E+03	29	0.0005	0.1	1E+00	1000	3000	ORSGL	1	1	Risk
HEXACHLOROETHANE	6E-01	2.50E-01				8	15d	5.00E+04	29	0.0005	0.1	4E-01	1000	3000	ORSGL	12	10	Risk
METHYL ETHYL KETONE	2E+02		42	32000	24	100	14a	2.75E+08	29	0.0005	0.1	2E-03	1000	350	ORSGL	1694003	50000	Ceiling
METHYL ISOBUTYL KETONE	2E+01		2	9700	25	50	14a	1.91E+07	29	0.0005	0.1	6E-03	1000	350	ORSGL	56663	50000	Ceiling
METHYL TERT BUTYL ETHER	1E+02					0.5	14f	4.80E+07	29	0.0005	0.1	2E-02	1000	700	ORSGL	82694	50000	Ceiling
METHYLENE CHLORIDE	6E+02	2.13E+00	600	540000	13	5	14f	1.67E+07	29	0.0005	0.1	1E-01	1000	5	ORSGL	91922	50000	Ceiling
METHYLNAPHTHALENE, 2-	1E+01			68	28	10	14c	2.60E+04	29	0.0005	0.1	1E-02	1000	3000	ORSGL	23930	10000	Solubility
NAPHTHALENE	1E+01		5	440	13	0.2	14g	3.10E+04	SES	0.0005	0.1	5E-02	1000	3000	ORSGL	5881	6000	Risk
PHENOL	5E+01			156.8	13	10	14c	8.00E+07	29	0.0005	0.1	5E-05	1000	3000	ORSGL	19548800	50000	Ceiling
STYRENE	2E+02	1.75E+00	5	1360	13	0.3	14g	3.00E+05	29	0.0005	0.1	1E-01	1000	100	MMCL	936	900	Bckgrnd-Air
TETRACHLOROETHANE, 1,1,1,2-		1.35E-01				5	14a	2.00E+05	29	0.0005	0.1	5E-01	1000	3000	ORSGL	6	6	Risk
TETRACHLOROETHANE, 1,1,2,2-	2E+01	1.72E-02	0.01	10470	13	2	14f	2.90E+06	29	0.0005	0.1	2E-02	1000	3000	ORSGL	22	20	Risk
TETRACHLOROETHYLENE	9E+02	1.92E+00	11	31730	13	1.5	14f	2.00E+05	SES	0.0005	0.1	8E-02	1000	5	MMCL	2635	3000	Bckgrnd-Air
TOLUENE	8E+01		29	30000	13	0.5	14f	5.35E+05	SES	0.0005	0.1	3E-01	1000	1000	MMCL	5853	6000	Risk
TRICHLOROBENZENE, 1,2,4-	2E+00		0.04	22000	27	1	14g	1.90E+04	29	0.0005	0.1	6E-02	1000	70	ORSGL	620	600	Risk
TRICHLOROETHANE, 1,1,1-	2E+02		30	65127	13	1.5	14f	7.30E+05	SES	0.0005	0.1	9E-01	1000	200	MMCL	4231	4000	Risk
TRICHLOROETHANE, 1,1,2-	1E+01	6.25E-02	30			0.5	14g	4.50E+06	29	0.0005	0.1	4E-02	1000	5	ORSGL	16112	20000	Bckgrnd-Air
TRICHLOROETHYLENE	4E+01	5.88E-01	5	1E+06	28	2	14f	1.10E+06	SES	0.0005	0.1	4E-01	1000	5	MMCL	268	300	Bckgrnd-Air
TRICHLOROPHENOL 2,4,6-		3.23E-01		0.3	13	10	14c	8.00E+05	29	0.0005	0.1	2E-04	1000	3000	ORSGL	36654	40000	ODOR
VINYL CHLORIDE	3E+00	1.19E-02		771244	13	1.5	14f	1.10E+03	29	0.0005	0.1	1E+00	1000	2	MMCL	0	2	PQL
XYLENES	6E+01		3	441	13	2.5	14f	1.71E+05	SES	0.0005	0.1	2E-01	1000	10000	MMCL	5564	6000	Risk

4.3.1 General Methodology

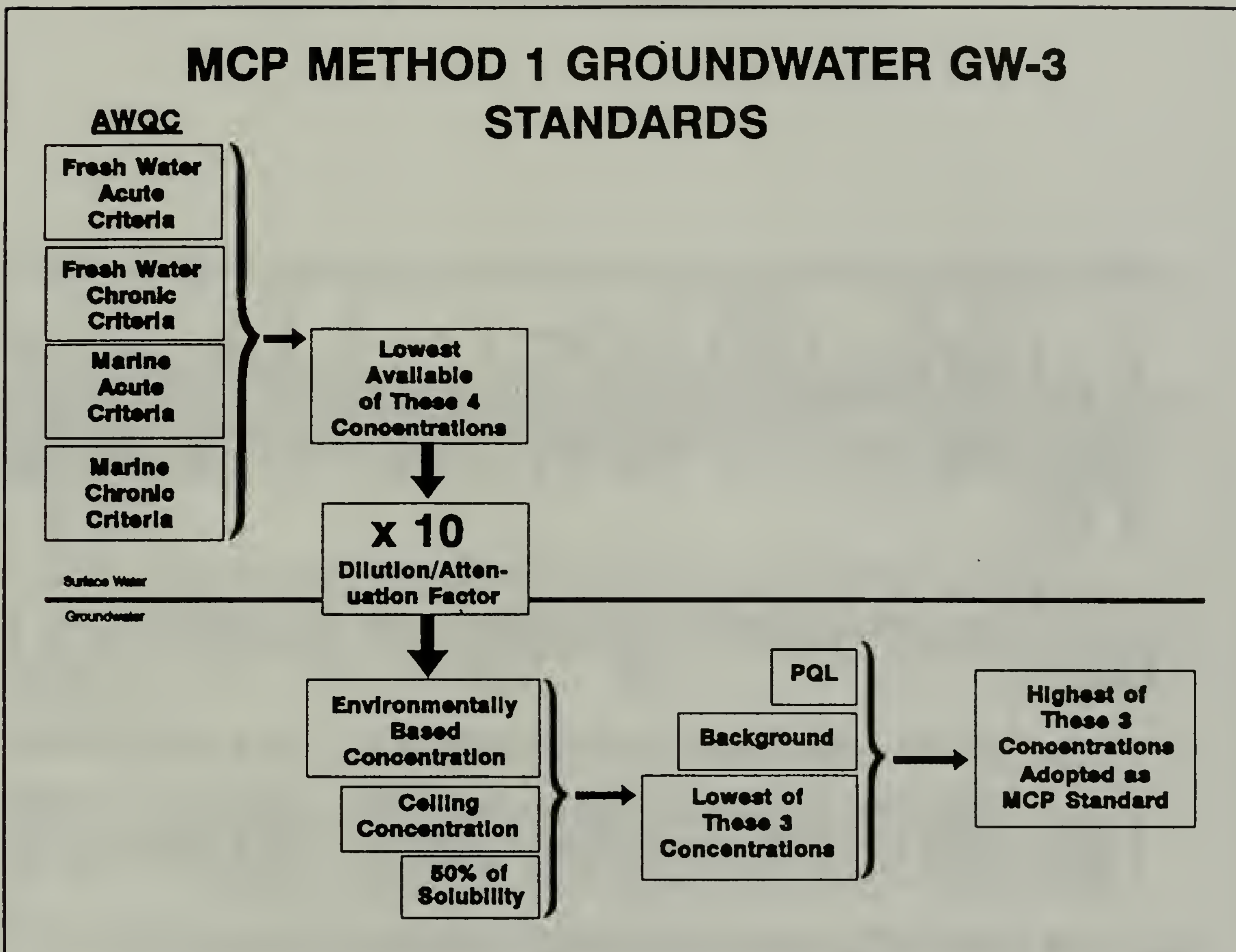
The sequential approach taken to the development of MCP GW-3 standards is as follows:

STEP	DESCRIPTION
1	The lowest of the ecologically-based U.S. EPA Ambient Water Quality Criteria is identified.
2	The lowest AWQC is multiplied by a dilution/attenuation factor of ten.
3	A value of ½ the solubility of the chemical is identified.
4	A ceiling concentration of 0.005% (50,000 μg/l) is noted.
5	The lowest of the three values identified in steps 2, 3, and 4 is chosen and carried through the process.
6	Practical Quantitation Limit (PQL) for an appropriately sensitive analytical method is identified.
7	A background concentration in groundwater is identified, if available.
8	The highest of the three values identified in steps 5, 6, and 7 is chosen. This value is adopted as the MCP GW-3 standard.

This process is diagramed in Figure 4-3.

FIGURE 4-3

DERIVATION OF GW-3 STANDARDS



4.3.5. Derivation of Category GW-3 Standards

The numerical derivation of the Category GW-3 Standards is given in Table 4.3. The table includes the Ambient Water Quality Criterion which is the basis of the standard, a preliminary concentration in groundwater, and the final concentration adopted as the GW-3 standard. The last column indicates the ultimate basis of the standard.

TABLE 4.3

DEVELOPMENT OF GW-3 STANDARDS

TABLE 4-3

GW-3 DERIVATION
310 CMR 40.0974(2)

OIL AND/OR HAZARDOUS MATERIAL	GW BACK-GROUND ug/L	WATER PQL ug/L	REF	Solu-bility ug/L	REF	Lowest Ambient Water Quality Criteria ug/L	Basis	Method 1 GROUNDWATER GW-3 STANDARD 310 CMR 40.0974(2) (Rounded) ug/L	Basis
ACENAPHTHENE		10	14c	3.42E+03	29	520	B	2000	Solubility
ACENAPHTHYLENE		0.5	14e	3.93E+03	24	300	C*	2000	Solubility
ACETONE		100	14a	1.00E+09	11			50000	Ceiling
ALDRIN		0.5	14e	1.70E+01	29	1.3	C	9	Solubility
ANTHRACENE		0.5	14e	1.29E+03	29	300	C*	600	Solubility
ANTIMONY		32	15b	-		30	PB	300	AWQC
ARSENIC	5.5	50	17	-		36	D	400	AWQC
BENZENE		0.5	14f	1.78E+06	SES	700	D	7000	AWQC
BENZO(a)ANTHRACENE		1	14e	1.00E+01	29	300	C*	5	Solubility
BENZO(a)PYRENE		0.5	14e	3.80E+00	29	300	C*	2	Solubility
BENZO(b)FLUORANTHENE		1	14e	1.40E+01	13	300	C*	7	Solubility
BENZO(g,h,i)PERYLENE		0.5	14e	2.60E-01	29	300	C*	0.1	Solubility
BENZO(k)FLUORANTHENE		1	14e	8.00E-01	30	300	C*	0.4	Solubility
BERYLLIUM		0.3	15b	-		5.3	B	50	AWQC
BIPHENYL, 1,1-		0.1	14e	7.50E+03	29			4000	Solubility
BIS(2-CHLOROETHYL)ETHER		28.5	15d	1.02E+07	29	238000	A*	50000	Ceiling
BIS(2-CHLOROISOPROPYL)ETHER		28.5	15d	1.70E+06	24	238000	A*	50000	Ceiling
BIS(2-ETHYLHEXYL)PHTHALATE		4	14e	1.30E+03	29	3	B*	30	AWQC
BROMODICHLOROMETHANE		2.5	14f	4.50E+06	13	6400	D*	50000	Ceiling
BROMOFORM		3.5	14f	3.20E+06	29	6400	D*	50000	Ceiling
BROMOMETHANE		0.55	14g	1.75E+07	29	6400	D*	50000	Ceiling
CADMIUM	4.2	4	15b	-		1.1	B	10	AWQC
CARBON TETRACHLORIDE		1.5	14f	8.00E+05	29	35200	A	50000	Ceiling
CHLORDANE		1.5	14e	5.60E+01	29	0.004	B,D	2	PQL
CHLOROANILINE, p-		20	14c	2.60E+06	30			50000	Ceiling
CHLOROBENZENE		0.5	14f	4.88E+05	29	50	B*	500	AWQC
CHLOROFORM		1	14f	9.30E+06	29	1240	B	10000	AWQC
CHLOROPHENOL, 2-		10	14c	2.85E+07	29	4380	A	40000	AWQC
CHROMIUM				-				2000	AWQC(ChIII)
CHROMIUM(III)		7	14d	-		210	B	2000	AWQC
CHROMIUM(VI)		0.5	14h	-		11	B	100	AWQC
CHRYSENE		1.5	14e	6.00E+00	29	300	C*	3	Solubility
CYANIDE		0.1	15a	1000000000	11	1	C	10	AWQC
DIBENZO(a,h)ANTHRACENE		0.5	14e	5.00E-01	29	300	C*	0.3	Solubility
DIBROMOCHLOROMETHANE		2	14f	4.00E+06	13	6400	D*	50000	Ceiling
DICHLOROBENZENE, 1,2- (o-DCB)		5	14f	1.45E+05	29	763	B*	8000	AWQC
DICHLOROBENZENE, 1,3- (m-DCB)		0.6	14g	1.23E+05	29	763	B*	8000	AWQC
DICHLOROBENZENE, 1,4- (p-DCB)		0.2	14g	7.90E+04	29	763	B*	8000	AWQC
DICHLOROBENZIDINE, 3,3'-		82.5	15d	3.10E+03	29			2000	Solubility
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)		0.012	15c	1.60E+02	29	0.6	A	6	AWQC
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)		0.05	15c	4.00E+01	29	14	C	20	Solubility
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)		0.3	15c	3.10E+00	29	0.001	B,D	0.3	PQL
DICHLOROETHANE, 1,1-		1	14f	5.50E+06	29			50000	Ceiling
DICHLOROETHANE, 1,2-		1	14f	8.69E+06	29	20000	B	50000	Ceiling

--------- file: TXINF4-3.wk1, 4/20/94 ---

Table 4.3, continued...

TABLE 4-3

GW-3 DERIVATION
310 CMR 40.0974(2)

OIL AND/OR HAZARDOUS MATERIAL	GW BACK-GROUND ug/L	WATER PQL ug/L	REF	Solu-bility ug/L	REF	Lowest Ambient Water Quality Criteria ug/L	Basis	Method 1 GROUNDWATER GW-3 STANDARD 310 CMR 40.0974(2) (Rounded) ug/L	Basis
DICHLOROETHYLENE, 1,1-		1	14f	2.10E+05	29	11600	A*	50000	Ceiling
DICHLOROETHYLENE, CIS-1,2-		0.6	14g	8.00E+05	29	11600	A*	50000	Ceiling
DICHLOROETHYLENE, TRANS-1,2-		0.3	14g	6.00E+05	29	11600	A*	50000	Ceiling
DICHLOROPHENOL, 2,4-		13.5	15d	4.50E+06	29	365	B	4000	AWQC
DICHLOROPROPANE, 1,2-		1	14f	2.70E+06	29	3040	D*	30000	AWQC
DICHLOROPROPENE, 1,3-		5	14a	2.70E+06	29	244	B*	2000	AWQC
DIELDRIN		0.1	15c	1.86E+02	29	0.0019	B,D	0.1	PQL
DIETHYL PHTHALATE		4	14e	8.96E+05	11	3	B*	30	AWQC
DIMETHYL PHTHALATE		1.5	14e	5.00E+06	29	3	B*	30	AWQC
DIMETHYLPHENOL, 2,4-		13.5	15d	7.87E+06	30	2120	A	20000	AWQC
DINITROPHENOL, 2,4-		210	15d	5.60E+06	29	150	B*	2000	AWQC
DINITROTOLUENE, 2,4-		28.5	15d	2.70E+05	29	230	B	2000	AWQC
DIOXIN		1E-05	19	1.93E-02	29	0.00001	B*	1E-04	AWQC
ENDOSULFAN		0.12	15c	1.50E+02	13	0.0087	D	0.1	PQL
ENDRIN		5	14e	2.60E+02	29	0.0023	B,D	5	PQL
ETHYLBENZENE		0.3	14g	1.61E+05	SES	430	C	4000	AWQC
ETHYLENE DIBROMIDE		0.3	14g	4.30E+06	29			50000	Ceiling
FLUORANTHENE		11	15d	2.65E+02	29	16	D	100	Solubility
FLUORENE		1	14e	1.90E+03	29	300	C*	1000	Solubility
HEPTACHLOR		1	14e	5.60E+01	29	0.0036	D	1	PQL
HEPTACHLOR EPOXIDE		1.5	14e	3.50E+02	29	0.0036	D	2	PQL
HEXACHLOROBENZENE		1	14e	1.10E+02	29	3.68	PB	40	AWQC
HEXACHLOROBUTADIENE		0.55	14g	2.00E+03	29	9.3	B	90	AWQC
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)		0.5	14e	7.00E+03	29	0.08	B	0.8	AWQC
HEXACHLOROETHANE		8	15d	5.00E+04	29	540	B	5000	AWQC
INDENO(1,2,3-cd)PYRENE		0.5	14e	5.30E-01	11	300	C*	0.3	Solubility
LEAD	8.8	1	15b	-		3.2	B	30	AWQC
MERCURY	0.95	0.2	14i	5.60E+01	29	0.012	B	1	Bckgrnd
METHOXYCHLOR		1.5	14e	4.00E+01	29	0.03	B,D	2	PQL
METHYL ETHYL KETONE		100	14a	2.75E+08	29			50000	Ceiling
METHYL ISOBUTYL KETONE		50	14a	1.91E+07	29			50000	Ceiling
METHYL MERCURY				-		0.012	B	0.1	AWQC
METHYL TERT BUTYL ETHER		0.5	14f	4.80E+07	29	7000	E	50000	Ceiling
METHYLENE CHLORIDE		5	14f	1.67E+07	29	6400	D*	50000	Ceiling
METHYLNAPHTHALENE, 2-		10	14c	2.60E+04	29	300	C*	3000	AWQC
NAPHTHALENE		0.2	14g	3.10E+04	SES	620	B	6000	AWQC
NICKEL		15	15b	-		8.3	D	80	AWQC
PENTACHLOROPHENOL		15	14e	1.40E+04	29	7.9	D	80	AWQC
PHENANTHRENE		1	14e	8.16E+02	29	4.6	PD	50	AWQC
PHENOL		10	14c	8.00E+07	29	2560	B	30000	AWQC
POLYCHLORINATED BIPHENYLS		0.325	14b	3.10E+01	11	0.014	B	0.3	PQL
PYRENE		0.5	14e	1.60E+02	29	300	C*	80	Solubility
SELENIUM		75	15b	-		5	B	80	PQL
SILVER	4.7	7	15b	-		0.12	B	7	PQL

--------- file: TXINF4-3.wk1, 4/20/94 --

Table 4.3, continued...

TABLE 4-3

GW-3 DERIVATION
310 CMR 40.0974(2)

OIL AND/OR HAZARDOUS MATERIAL	GW BACK-GROUND ug/L	WATER PQL ug/L	REF	Solu-bility ug/L	REF	Lowest Ambient Water Quality Criteria ug/L	Basis	Method 1 GROUNDWATER GW-3 STANDARD 310 CMR 40.0974(2) (Rounded) ug/L	Basis
STYRENE		0.3	14g	3.00E+05	29			50000	Ceiling
TETRACHLOROETHANE, 1,1,1,2-		5	14a	2.00E+05	29	9320	A	50000	Ceiling
TETRACHLOROETHANE, 1,1,2,2-		2	14f	2.90E+06	29	2400	B	20000	AWQC
TETRACHLOROETHYLENE		1.5	14f	2.00E+05	SES	450	D	5000	AWQC
THALLIUM		40	15b	-		40	B	400	AWQC
TOLUENE		0.5	14f	5.35E+05	SES	5000	D	50000	AWQC
TOTAL PETROLEUM HYDROCARBONS								50000	Ceiling
TRICHLOROBENZENE, 1,2,4-		1	14g	1.90E+04	29	50	B*	500	AWQC
TRICHLOROETHANE, 1,1,1-		1.5	14f	7.30E+05	SES	18000	A	50000	Ceiling
TRICHLOROETHANE, 1,1,2-		0.5	14g	4.50E+06	29	9400	B	50000	Ceiling
TRICHLOROETHYLENE		2	14f	1.10E+06	SES	2000	C	20000	AWQC
TRICHLOROPHENOL, 2,4,5-		10	14c	1.19E+06	29	11	D	100	AWQC
TRICHLOROPHENOL 2,4,6-		10	14c	8.00E+05	29	970	B	10000	AWQC
VINYL CHLORIDE		1.5	14f	1.10E+03	29			600	Solubility
XYLENES		2.5	14f	1.71E+05	SES			50000	Ceiling
ZINC		2	15b	-		86	D	900	AWQC

BASIS OF AWQC:
A = FRESH WATER ACUTE CRITERIA
B = FRESH WATER CHRONIC CRITERIA
C = MARINE ACUTE CRITERIA
D = MARINE CHRONIC CRITERIA
* = WQC for a Group of Chemicals (such as "PAHs").
E = Derived by MA DEP/ORS
P = Proposed value

BASIS OF GW-3 STANDARDS IN TEXT

4.4 UPPER CONCENTRATION LIMITS

The Upper Concentration Limits (UCLs) in Groundwater (310 CMR 40.0996(4)) are applicable when risk characterization Method 2 or Method 3 is used to evaluate the potential risk of harm to health, public welfare and the environment. ***Upper Concentration Limits are not used in risk characterization Method 1*** as sites meeting the Method 1 Standards meet the Upper Concentration Limits, by definition.

The categorization scheme devised to determine the "current and foreseeable use(s)" of the groundwater essentially clarifies <u>why</u> the Department is concerned about contamination in groundwater and related human and/or ecological impacts. Our ability to comprehensively describe (qualitatively or quantitatively) potential impacts is limited, however, particularly impacts which may only become evident in the future. The revised MCP defines areas of particular interest (categories GW-1, GW-2 and GW-3), and allows some flexibility to establish alternative cleanup requirements using risk assessment in Methods 2 and 3. The Upper Concentration Limits identify contamination which may pose a significant risk of harm to public welfare and the environment <u>in the future</u>, and to minimize the incremental contributions to anthropogenic background. The Department views all groundwater as a resource of the Commonwealth and does <u>not</u> endorse the general degradation of the groundwater.

The revised MCP contains several features intended to provide protection to all groundwater, including: (a) the requirement to use the best remedial action management approaches (BRAMA) to characterize a site (310 CMR 40.0191); (b) the requirement to eliminate all continuing sources of release to the environment (310 CMR 40.1003(5)); and (c) the list of Upper Concentration Limits applicable to all groundwater as public welfare environmental resource standards (310 CMR 40.0994(3) and 310 CMR 40.0995(5)).

A disposal site may qualify for a Class C Response Action Outcome (RAO), even if the concentrations of oil or hazardous material remaining at the disposal site exceed the Upper Concentration Limits. Exceedance of these standards is interpreted to indicate significant risk of harm to public welfare and/or environmental resources in the future, and thus a Class C RAO may be appropriate if, for current conditions, a level of no significant risk of harm to health, safety, public welfare and the environment exists or has been achieved.

The UCLs are simply 10 fold multiple of the highest exposure-related (GW-1, GW-2 or GW-3) standard, capped at a maximum concentration of 100,000 $\mu g/L$, or 0.01 % and adjusted for solubility. The Upper Concentration Limits in Groundwater are listed in Table 1.1.

5.0 SOIL

MCP Numerical Standards have been derived for three categories of soil, as described in the following subsections. The three categories were developed to address a broad range of potential human exposures (Categories S-1, S-2 and S-3), plus an "upper concentration limit" is identified to protect against general environmental degradation.

The applicability of a particular soil category depends upon both the accessibility of the soil (measured primarily by depth) and the human activities which may take place at the surface. Within a soil category there are further sub-categories which are identified by groundwater type: the soil standards within these sub-categories have been modified by the potential for a contaminant to leach and impact the site groundwater.

For Method 1 risk characterizations, the applicable soil standard is identified by the combination of soil and groundwater categories. These standards consider both the risks associated with direct contact (ingestion and dermal contact) exposures associated with the soil and the potential for material to leach from the soil and impact the groundwater. The Method 1 Soil Category S-1, S-2, and S-3 Standards are listed in Tables 2, 3 and 4 (respectively) of the Massachusetts Contingency Plan (310 CMR 40.0975(6)(a), (b) and (c)).

For Method 2 risk characterizations, the Method 1 Soil Standards may be adjusted considering site-specific soil leaching characteristics, but *not* to account for other exposure factors (310 CMR 40.0985). The direct contact component of the Method 1 Soil Standards is thus a limiting factor to the Method 2 modifications. These Direct Contact levels are listed in Table 5 (310 CMR 40.0985(6)) of the MCP.

Note that the derivation of the Direct Contact Standards is presented first in the following sections, then the derivation of the leaching-based soil concentrations is described. Both the direct contact and leaching-based concentrations are components of the Method 1 Standards. The direct contact values are common to both the Method 1 and Method 2 Soil Standards, so while these numbers are labelled the "Method 2 Standards", they are also the first step in the derivation of the Method 1 Soil Standards and, as a result, are presented first.

The soil exposure assessment described in this section is based upon an ongoing project within the Department to develop methodology for deriving soil advisory levels (MA DEP, 1991a).

5.1 HUMAN EXPOSURE CATEGORIES: S-1, S-2 AND S-3

The derivation of MCP Soil Standards for Categories S-1, S-2 and S-3 share a common methodology which is detailed in this section. The specific exposure factors which were used for each category are described in later subsections.

The three human exposure categories are intended to describe a range of potential exposure situations which are commonly found at c.21E sites.

> **It is clear that there are as many specific exposure scenarios as there are sites, which is why the risk assessor, LSP and PRP have the option of characterizing the risk of harm to health by MCP Method 3.**

Given the need to generalize about exposure situations, there has been concern that the application of "typical" scenarios to a given site may result in standards which are "over-" or "under-protective". In practice, however, variations in the exposure assumptions do not produce dramatic changes in the resulting standards. The risk-based concentrations estimated for the three soil categories span approximately one order-of-magnitude (a factor of 10), despite the fact that the exposure scenarios are significantly different.

5.1.1 General Methodology

The **Method 2** Direct Contact standards for each soil category are derived in a sequential fashion, as follows:

STEP	DESCRIPTION
1	Standard toxicity information and risk assessment is used to identify risk-based concentrations which are associated with (a) 20% of an allowable daily intake (based on non-cancer health effects), and (b) an excess lifetime cancer risk equal to one-in-one million. The lowest of these two factors is carried through the process.
2	A Practical Quantitation Limit (PQL) for an appropriately sensitive analytical method is identified.
3	A "background" concentration is identified, if available.
4	The highest of the three values (risk-based, PQL, background) is identified.
5	A ceiling concentration is noted. The ceiling concentration varies by category, as described below.
6	The lowest of the concentrations identified in steps 4 and 5 is the Method 2 Direct Contact soil standard.

The Method 1 Soil Standards, which consider leaching, are derived in a similar manner, but a leaching factor is incorporated in step (1):

STEP	DESCRIPTION
1	Standard toxicity information and risk assessment is used to identify risk-based concentrations which associated with (a) 20% of an allowable daily intake (based on non-cancer health effects), and (b) an excess lifetime cancer risk equal to one-in-one million. The leaching-based concentration (i.e., a level in soil which is considered protective of the applicable groundwater standard is identified. (See Section 5.2) The lowest of these three factors is carried through the process.
2	A Practical Quantitation Limit (PQL) for an appropriately sensitive analytical method is identified.
3	A "background" concentration is identified, if available.
4	The highest of the three values (risk-/leaching-based, PQL, background) developed in steps 1, 2 and 3 is identified.
5	A ceiling concentration is noted. The ceiling concentration varies by category, as described below.
6	The lowest of the concentrations identified in steps 4 and 5 is becomes the Method 1 Soil Standard applicable in the specified groundwater area.

The general methodology for the development of Method 2 Direct Contact Soil Standards is outlined in Figure 5-1. The methodology for the development of the Method 1 Soil Standards (considering potential leaching to groundwater) is outlined in Figure 5-2.

FIGURE 5-1

DERIVATION OF METHOD 2
DIRECT CONTACT SOIL STANDARDS

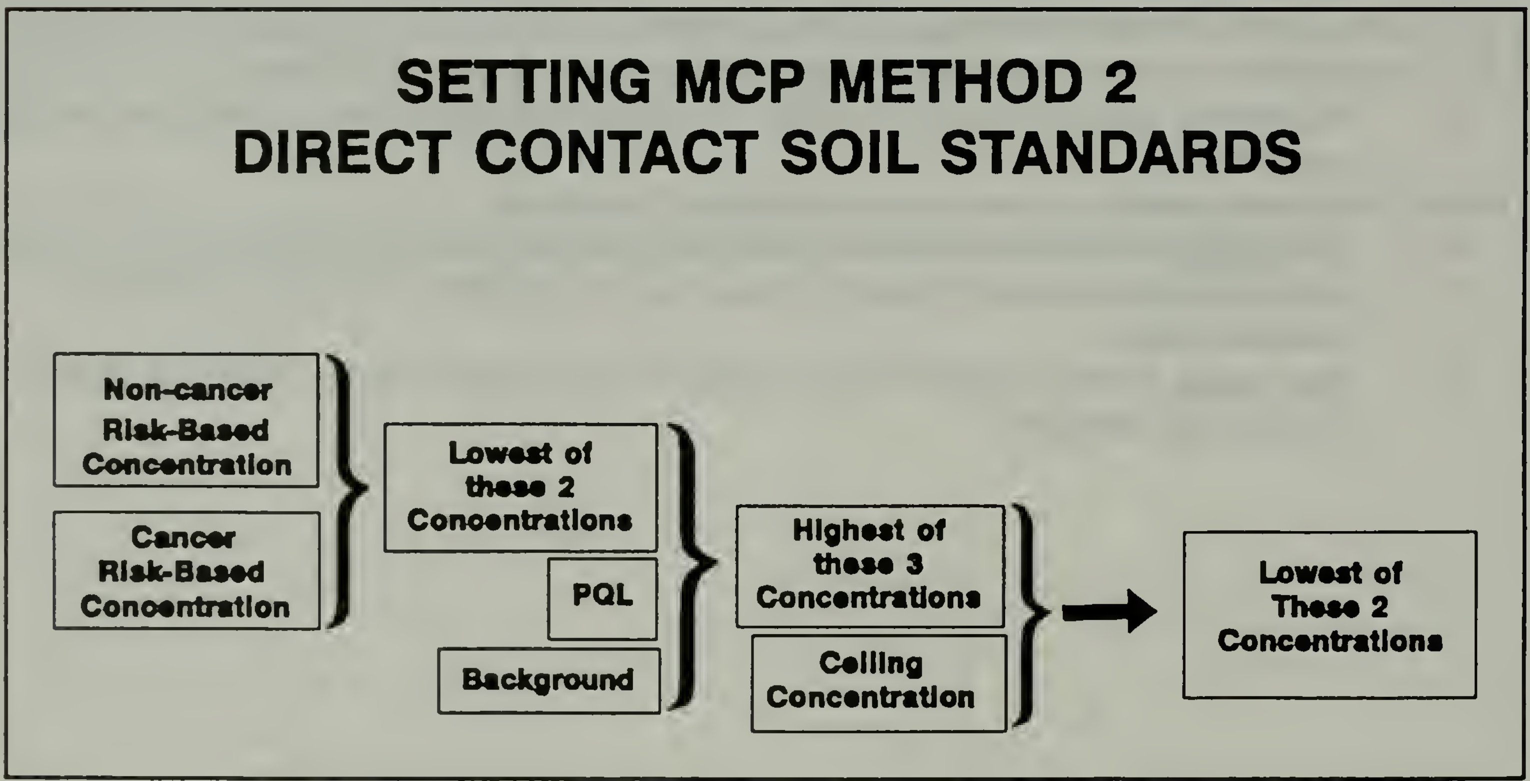
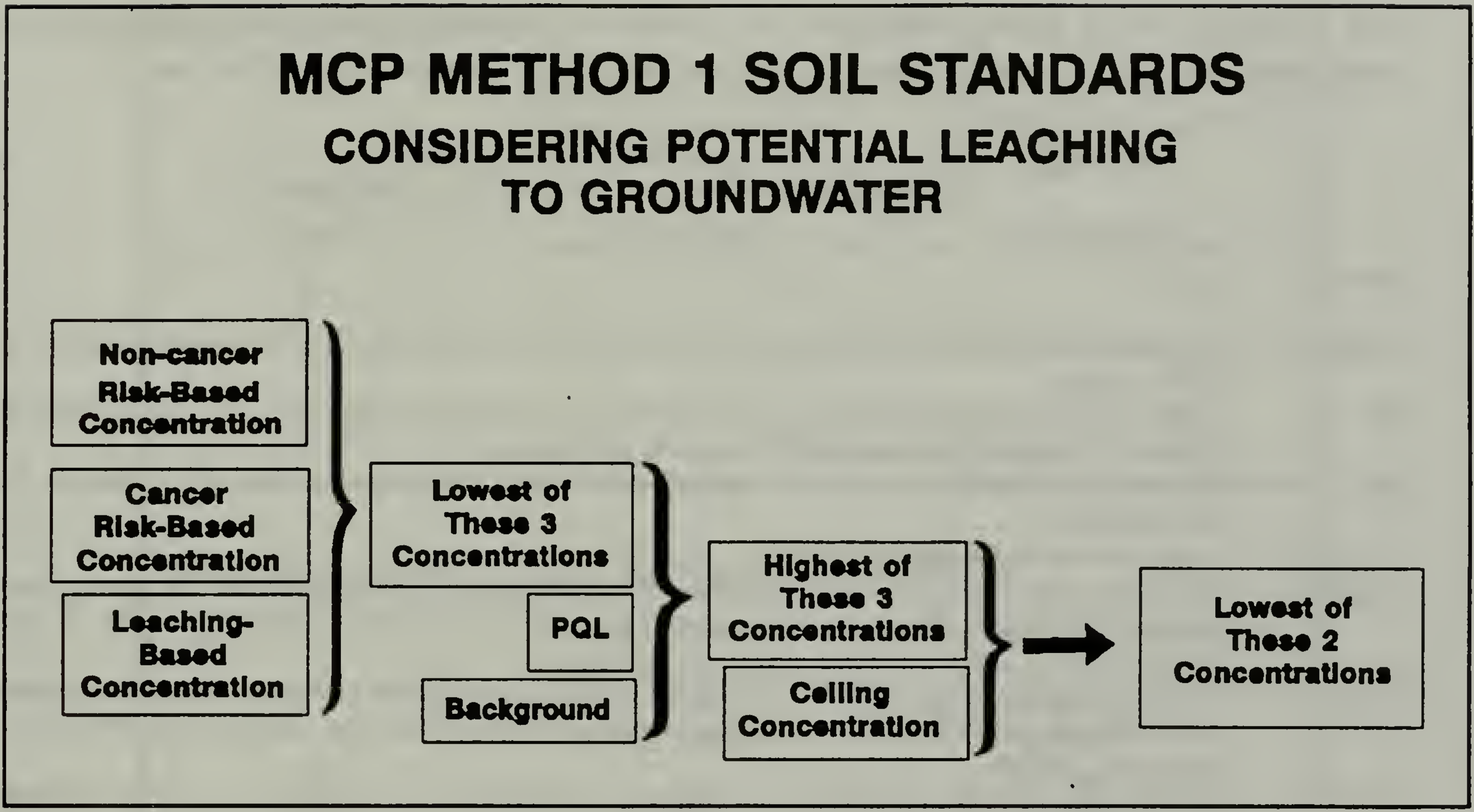


FIGURE 5-2

DERIVATION OF METHOD 1
SOIL STANDARDS



5.1.2 Risk Assessment Equations

Incidental ingestion of and dermal contact with surface soils and dust have been identified as potential exposures of concern for both children and adults in the development of the soil standards. The receptor's exposure to contaminated soil and dust varies according to the activities by which the receptor comes into contact with the soil.

The exposure rate normalized to bodyweight is most often the expression of exposure which is of most toxicological significance. This concept is particularly important in the assessment of direct soil contact because the soil exposure rate normalized to bodyweight is not constant over the lifetime, but rather is relatively high in young children and falls off to a lower, fairly constant level in adults.

In developing the standards, chemical exposures were treated as a function of the concentration of an OHM in soil and the average soil exposure rate normalized to bodyweight for various exposure durations and receptor age groups. The concentrations of OHM were assumed to remain constant in soil over time. As described below, the soil ingestion rates and soil dermal contact rates used here incorporate the frequency and duration of exposure and the appropriate averaging period.

The equation used to develop risk-based concentrations considering potential non-carcinogenic effects associated with direct contact with contaminated surface soil is given as:

$$[OHM]_{soil} = \frac{0.2 \, x \, RfD \, x \, C}{(NADSIR \, x \, RAF_1) + (NADSCR \, x \, RAF_2)} \quad \textbf{(9)}$$

The equation used to develop risk-based concentrations considering potential carcinogenic effects associated with direct contact exposure with contaminated surface soil is given as:

$$[OHM]_{soil} = \frac{ELCR \ x \ C}{((NLADSIR \, x \, RAF_3) + (NLADSCR \, x \, RAF_4)) \, x \, CSF} \quad \textbf{(10)}$$

Where:

$[OHM]_{soil}$ =	A risk-based (non-cancer or cancer risk) concentration, in soil, for the oil of hazardous material. In units: mg/kg.
0.2 =	A 20% Source Allocation Factor, used to insure that only 20% of an allowable daily intake of the oil or hazardous material may come from exposure to the site soil.
RfD =	The oral Reference Dose or substitute toxicity value identified for the oil or hazardous material. In units of: mg/kg/day.
C =	Units Conversion Factor: 10^6 mg/kg
NADSIR =	The Normalized Average Daily Soil Ingestion Rate (normalized to bodyweight) for the exposure period of concern. (Table 5.1) These values are rates of soil ingestion (not rates of OHM ingestion). In units: mg_{soil}/kg/day.
NADSCR =	The Normalized Average Daily Soil Dermal Contact Rate (normalized to bodyweight) for the exposure period of concern. (Table 5.1) These values are rates of soil contact (not contact with OHM). In units: mg_{soil}/kg/day.
RAF =	The Relative Absorption Factors for soil ingestion or dermal contact and threshold or cancer health effects (a chemical-, medium-, route- , and health endpoint-specific value). Dimensionless.
ELCR =	Target Excess Lifetime Cancer Risk: 1×10^{-6} (dimensionless).
NLADSIR =	Time-weighted Normalized Lifetime Average Daily Soil Ingestion Rate (normalized to bodyweight). (Table 5.1) This value represents the exposure during the exposure period averaged over a lifetime, not a lifetime exposure. In units: mg_{soil}/kg/day.
NLADSCR =	Time-weighted Normalized Lifetime Average Daily Soil Dermal Contact Rate (normalized to bodyweight). (Table 5.1) This value represents the exposure during the exposure period averaged over a lifetime, not a lifetime exposure. In units: mg_{soil}/kg/day.
CSF =	The oral Cancer Slope Factor for the oil or hazardous material. In units of: $(mg/kg/day)^{-1}$

The Normalized Average Daily Soil Ingestion Rate, (NADSIR) and the Normalized Average Daily Soil Contact Rate (NADSCR) were used to calculate the non-cancer risk-based concentrations. The Normalized Lifetime Average Daily Soil Ingestion Rates (NLADSIR) and the Normalized Lifetime Average Daily Soil Contact Rates (NLADSCR) are used to calculate the cancer risk-based concentrations. The numerical value for each of these soil exposure rates and for each of the soil Categories is shown in Table 5.1. Appendices A-C document in a step-by-step approach the derivation of the soil ingestion rates and the soil dermal contact rates summarized in Table 5.1. The average exposure rates can be reproduced from the information in these tables and the references cited. All of these exposure rates are based on a methodology described in the **DRAFT Development of Soil Advisory Levels, Technical Support Document** (MADEP, 1991a).

TABLE 5.1

SUMMARY OF SOIL INGESTION AND DERMAL CONTACT RATES

NON-CANCER EFFECTS

Soil Category	Normalized (to BW) Average Daily Soil Ingestion Rate (NADSIR) mg_{soil}/kg/day	Normalized (to BW) Average Daily Soil/Skin Contact Rate (NADSCR) mg_{soil}/kg/day
S-1	3.1	28.5
S-2	0.29	15.2
S-3	0.63	32.5

NON-THRESHOLD (CARCINOGENIC) EFFECTS

Soil Category	Normalized (to BW) Lifetime Average Daily Soil Ingestion Rate (NLADSIR) mg_{soil}/kg/day	Normalized (to BW) Lifetime Average Daily Soil/Skin Contact Rate (NLADSCR) mg_{soil}/kg/day
S-1	0.41	7.3
S-2	0.11	5.48
S-3	0.029	1.5

The derivations of these values are presented in Appendices A (S-1), B (S-2) and C (S-3).

5.1.3 Exceptions To This Methodology

For five chemicals the MCP Numerical Standards represent exceptions to the general methodology described in the previous sections. These chemicals are cyanide, lead, polychlorinated biphenyls (PCBs), Total Petroleum Hydrocarbons and zinc.

The Category S-1 cyanide standard is derived from an evaluation of potential acute effects associated with a *one-time* exposure to cyanide in soil. The derivation of this value is contained in an earlier MA DEP document (1990c).

For lead, PCBs and zinc, the exceptions arise from Massachusetts regulations (310 CMR 32) which allow the unrestricted land application of Type I sludge material at specific concentrations. Consistent with the decision to adopt existing drinking water standards and guidelines as GW-1 standards, the Department has determined that, for these chemicals, MCP Method 1 standards

are set at a concentration equal to the Type I sludge standards when that standard is *higher* than the value calculated following the MCP approach.

For zinc, the Category S-1 risk-based concentration derived using the MCP process is greater than the Type I sludge standard, but the ceiling concentration of 1,000 μg/gram which would normally be applied in this Category would render the S-1 standard more stringent than the Type I sludge standard. Therefore, for this chemical only, the ceiling concentration is not applied, and the Category S-1 standard is set at 2,500 μg/gram.

For lead, the Category S-1 risk-based concentration derived using the MCP process is less than the Type I sludge standard. The Type I sludge standard is therefore adopted as the Category S-1 lead standard on an interim basis while the Department reviews its policy on the regulation of this chemical.

For polychlorinated biphenyls (PCBs), the risk-based concentrations derived using the MCP process for all the soil categories are less than the Type I sludge standard. The Type I sludge standard is therefore adopted as the MCP soil standard on an interim basis while the Department reviews its policy on the regulation of this chemical.

For Total Petroleum Hydrocarbons (TPH) default standards were identified based upon the assignment of toxicity values to the alkane and aromatic/alkene fractions (each fraction is assumed to be approximately 50% of the mixture). Half the mixture was assumed to be composed of alkanes exhibiting toxicity similar to that of n-hexane (Reference Dose = 0.06 mg/kg/day) with the remainder of the mixture assumed to be composed of alkenes and/or aromatics exhibiting toxicity similar to that of pyrene (Reference Dose = 0.03 mg/kg/day). As n-hexane and pyrene are associated with effects on different target organs (the nervous system and the kidney, respectively), the risk-based concentrations for each fraction were summed to yield the standard for the TPH mixture. The development of the TPH standard takes a health protective approach in addressing the uncertainty which exists in the composition of a given TPH mixture by assigning conservative toxicity values to each fraction (alkanes and alkenes/aromatics). The toxicity of each of the hundreds of chemicals which comprise the mixture would be expected to be, on average, less than that of the reference compounds chosen. This approach was based upon initial efforts by MADEP to develop a health-based alternative to the TPH parameter. This draft policy (MADEP, 1993) will be part of the DEP BWSC comprehensive *Petroleum Policy*, which will address site investigation and analytical issues as well.

5.1.4 Soil Category S - 1

The Soil Category S-1 standards are based upon a residential exposure scenario in which the potential receptor may come into contact with the contaminated soil in their yard while playing or gardening.

For non-cancer health effects, the receptor of concern is a young child (aged 1 to 8 years) who comes into contact with house dust of soil origin (indoors) and the contaminated soil outdoors.

For carcinogenic effects, the receptor of concern is the resident (aged 0 to 30 years) who comes into contact with the soil as described for the youth and while working/gardening in their yard as an adult.

FREQUENCY OF EXPOSURE:

* **The young child (1 to 6 years) is assumed to be in contact with the house dust every day from October through April (212 days).**

* **The child (1 to 8 years) is assumed to be in contact with the outdoor soil every day from May through September (153 days).**

* **The adult (9 - 30 years) is assumed to come into contact with the outdoor soil every day from May to September (153 days).**

INTENSITY OF EXPOSURE:

* **Household dust ingestion rates varied from 2 to 31 mg soil per day exposed (age dependent). This pathway was only evaluated for the 1 to 6 year old.**

* **Outdoors the child is assumed to ingests 100 mg of soil per day exposed (ages 1 to 6 years) and 50 mg of soil per day exposed (ages 6 to 8 years).**

* **Adults (9 to 30 years) are assumed to ingest 50 mg of soil per day exposed.**

* **Indoors in the winter, it is assumed that the hands of the 1 to 6 year old is exposed to the house dust.**

* **In the summer, it is assumed that the hands, arms, legs and feet of the child (1 to 18 years) are exposed to the soil.**

* **For the adult (18 to 30 years), only the hands, forearms, lower legs and feet are assumed to be exposed.**

BODY WEIGHT:

* **Typical (median) age-specific body weights were employed.**

The derivations of the Category S-1 soil ingestion and soil contact rates are given in Appendix A. Table 5.2 lists the S-1 Method 2 Direct Contact soil standards, and includes the calculated risk-based concentrations, background values, Odor Indices, vapor pressures, and Practical Quantitation Limits used to determine the S-1 Method 2 Direct Contact soil standards. The last column indicates the ultimate basis of the standard. Note that the derivation of the Category S-1 Method 1 Standards uses this information in combination with leaching considerations, as described in Section 5.2.

TABLE 5.2

TABLE 5-2

METHOD 2 DIRECT CONTACT S-1 DERIVATION 310 CMR 40.0985(6) OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING	Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	Method 2, Direct Contact SOIL S-1 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
ACENAPHTHENE	0.5	0.66	14c			1000	Non-Odor	1.4E+03		1000	Ceiling
ACENAPHTHYLENE	0.5	0.66	14c		2.90E-02	100	Non-Odor	1.0E+03		100	Ceiling
ACETONE		0.1	14a	20.77	270	500	Odor-2	3.4E+03		500	Ceiling
ALDRIN		0.00268	14b	5.87E-06	2.30E-05	1000	Non-Odor	5.9E-01	0.03	0.03	Cancer Risk
ANTHRACENE	0.5	0.66	14c		1.70E-05	1000	Non-Odor	5.3E+03		1000	Ceiling
ANTIMONY		6.4	14d			1000	Non-Odor	1.3E+01		10	Noncancer Risk
ARSENIC	32	10.6	14d			1000	Non-Odor	1.5E+01	0.91	30	Background
BENZENE		0.005	14a	63.33	95	500	Odor-2	1.9E+02	34.69	30	Cancer Risk
BENZO(a)ANTHRACENE	0.5	0.66	14c		5.00E-09	1000	Non-Odor	1.0E+03	0.07	0.7	PQL
BENZO(a)PYRENE	0.5	0.66	14c		5.00E-09	1000	Non-Odor	1.0E+03	0.07	0.7	PQL
BENZO(b)FLUORANTHENE	0.5	0.66	14c		NA	1000	Non-Odor	1.0E+03	0.07	0.7	PQL
BENZO(g,h,i)PERYLENE	0.5	0.66	14c		1.00E-10	1000	Non-Odor	1.0E+03		1000	Ceiling
BENZO(k)FLUORANTHENE	0.5	0.66	14c		9.59E-11	1000	Non-Odor	1.0E+03	0.07	0.7	PQL
BERYLLIUM		0.06	14d			1000	Non-Odor	2.5E+02	0.37	0.4	Cancer Risk
BIPHENYL, 1,1-		0.05	14c			1000	Non-Odor	1.9E+03		1000	Ceiling
BIS(2-CHLOROETHYL)ETHER		0.66	14c	14.49	7.10E-01	500	Odor-2		0.12	0.7	PQL
BIS(2-CHLOROISOPROPYL)ETHER		0.66	14c	2.66	8.50E-01	500	Odor-2	2.5E+02	1.85	2	Cancer Risk
BIS(2-ETHYLHEXYL)PHTHALATE		0.66	14c			1000	Non-Odor	1.1E+03	128.47	100	Cancer Risk
BROMODICHLOROMETHANE		0.005	14a		50	100	Volatility	6.7E+02	14.15	10	Cancer Risk
BROMOFORM		0.005	14a	4.31	5.6	500	Odor-2	6.4E+02	111.04	100	Cancer Risk
BROMOMETHANE		0.01	14a	71.00	1420	500	Odor-2	4.7E+01		50	Noncancer Risk
CADMIUM		0.8	14d			1000	Non-Odor	2.8E+01		30	Noncancer Risk
CARBON TETRACHLORIDE		0.005	14a	11.30	113	500	Odor-2	2.4E+01	6.75	7	Cancer Risk
CHLORDANE		0.00938	14b	7.12E-05	1.00E-05	1000	Non-Odor	2.7E+00	0.99	1	Cancer Risk
CHLOROANILINE, p-		1.3	14c		1.50E-02	100	Non-Odor	1.3E+02		100	Ceiling
CHLOROBENZENE		0.005	14c	53.64	11.8	500	Odor-2	6.7E+02		500	Ceiling
CHLOROFORM		0.005	14a	1.88	160	500	Odor-2	3.4E+02	143.80	100	Cancer Risk
CHLOROPHENOL, 2-		0.66	14c			1000	Non-Odor	9.5E+01		100	Noncancer Risk
CHROMIUM(III)		1.4	14d		NA	1000	Non-Odor	4.7E+04		1000	Ceiling
CHROMIUM(VI)	105		14h		NA	1000	Non-Odor	1.8E+02		200	Noncancer Risk
CHRYSENE	0.5	0.66	14c		6.30E-09	1000	Non-Odor	1.0E+03	0.07	0.7	PQL
CYANIDE		1	16	1068.97	620	100	Odor-1	* 1.0E+02		100	Noncancer Risk *
DIBENZO(a,h)ANTHRACENE	0.5	0.66	14c		1.00E-10	1000	Non-Odor	1.6E+03	0.13	0.7	PQL
DIBROMOCHLOROMETHANE		0.005	14a		76	100	Volatility	6.7E+02	10.44	10	Cancer Risk
DICHLOROBENZENE, 1,2- (o-DCB)		0.66	14c	0.03	1.5	100	Volatility	3.0E+03		100	Ceiling
DICHLOROBENZENE, 1,3- (m-DCB)		0.66	14c	0.03	1.5	100	Volatility(	3.0E+03		100	Ceiling(o-DCB)
DICHLOROBENZENE, 1,4- (p-DCB)		0.66	14c	10.00	1.8	500	Odor-2		36.55	40	Cancer Risk
DICHLOROBENZIDINE, 3,3'-		1.3	14c		4.50E-09	1000	Non-Odor		0.51	1	PQL
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)		0.00737	14b		1.00E-06	1000	Non-Odor		2.23	2	Cancer Risk
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)		0.00268	14b		6.50E-06	1000	Non-Odor		1.57	2	Cancer Risk
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)		0.00804	14b		1.50E-07	1000	Non-Odor	1.1E+01	1.57	2	Cancer Risk
DICHLOROETHANE, 1,1-		0.005	14a	0.47	234	100	Volatility	2.6E+03		100	Ceiling
DICHLOROETHANE, 1,2-		0.005	14a	13.17	79	500	Odor-2	6.7E+02	9.64	10	Cancer Risk
DICHLOROETHYLENE, 1,1-		0.005	14a	1.18	591	500	Odor-2	3.0E+02	1.43	1	Cancer Risk

---------------- file: TXINF5-2.wk1, 4/20/94 ----------------

TABLE 5-2

METHOD 2 DIRECT CONTACT S-1 DERIVATION 310 CMR 40.0985(6) ----------------- OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING	Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	Method 2, Direct Contact SOIL S-1 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
DICHLOROETHYLENE, CIS-1,2-		0.005	14a		202	100	Volatility	3.4E+02		100	Ceiling
DICHLOROETHYLENE, TRANS-1,2-		0.005	14a	19.47	331	500	Odor-2	6.7E+02		500	Ceiling
DICHLOROPHENOL, 2,4-		0.66	14c	0.32	6.70E-02	100	Non-Odor	4.1E+01		40	Noncancer Risk
DICHLOROPROPANE, 1,2-		0.005	14a	168.00	42	100	Odor-1		7.86	8	Cancer Risk
DICHLOROPROPENE, 1,3-		0.005	14a	43.00	43	500	Odor-2	6.8E+00	2.97	3	Cancer Risk
DIELDRIN		0.00134	14b		1.80E-07	1000	Non-Odor	9.8E-01	0.03	0.03	Cancer Risk
DIETHYL PHTHALATE		0.66	14c			1000	Non-Odor	4.4E+04		1000	Ceiling
DIMETHYL PHTHALATE		0.66	14c			1000	Non-Odor	3.9E+04		1000	Ceiling
DIMETHYLPHENOL, 2,4-		0.66	14c			1000	Non-Odor	3.8E+02		400	Noncancer Risk
DINITROPHENOL, 2,4-		3.3	14c		NA	1000	Non-Odor	3.8E+01		40	Noncancer Risk
DINITROTOLUENE, 2,4-		0.66	14c		5.10E-03	1000	Non-Odor	5.9E+01	1.08	1	Cancer Risk
DIOXIN		1.0E-06	19		7.40E-10	1000	Non-Odor		0.00	4E-06	Cancer Risk
ENDOSULFAN		0.00938	14b		1.00E-05	1000	Non-Odor	1.1E+00		1	Noncancer Risk
ENDRIN		0.00402	14b		2.00E-07	1000	Non-Odor	5.9E+00		6	Noncancer Risk
ETHYLBENZENE		0.005	14a	4.35	10	500	Odor-2	2.3E+03		500	Ceiling
ETHYLENE DIBROMIDE		0.005	14a	0.46	12	100	Volatility	6.7E-01	0.01	0.01	Cancer Risk
FLUORANTHENE	0.5	0.66	14c		5.00E-06	1000	Non-Odor	9.1E+02		900	Noncancer Risk
FLUORENE	0.5	0.66	14c			1000	Non-Odor	9.1E+02		900	Noncancer Risk
HEPTACHLOR		0.00201	14b	0.01	3.00E-04	1000	Non-Odor	1.1E+01	0.12	0.1	Cancer Risk
HEPTACHLOR EPOXIDE		0.05561	14b	1.37E-04	2.60E-06	1000	Non-Odor	3.0E-01	0.06	0.06	Cancer Risk
HEXACHLOROBENZENE		0.66	14c		1.09E-05	1000	Non-Odor	2.4E+01	0.46	0.7	PQL
HEXACHLOROBUTADIENE		0.66	14c	1.17E-03	1.50E-01	100	Non-Odor	4.5E+01	6.86	7	Cancer Risk
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)		0.00268	14b		9.40E-06	1000	Non-Odor	6.8E+00	0.41	0.4	Cancer Risk
HEXACHLOROETHANE		0.66	14b		4.00E-01	100	Non-Odor	6.3E+00	9.26	6	Noncancer Risk
INDENO(1,2,3-cd)PYRENE	0.5	0.66	14c		1.00E-09	1000	Non-Odor	1.0E+03	0.07	0.7	PQL
LEAD	69	8.4	14d			1000	Non-Odor	8.7E+01		300	* Sludge Stnd
MERCURY	1	0.1	14i		1.20E-03	1000	Non-Odor	1.3E+01		10	Noncancer Risk
METHOXYCHLOR		0.11792	14b		1.40E-06	1000	Non-Odor	1.1E+02		100	Noncancer Risk
METHYL ETHYL KETONE		0.1	14a	9.09	100	500	Odor-2	2.0E+04		500	Ceiling
METHYL ISOBUTYL KETONE		0.05	14a	100.00	10	100	Odor-1	1.7E+03		100	Ceiling
METHYL MERCURY						1000	Non-Odor	6.8E+00		7	Noncancer Risk
METHYL TERT BUTYL ETHER		0.05	14f		245	100	Volatility	1.7E+02		100	Ceiling
METHYLENE CHLORIDE		0.005	14a	2.68	429	500	Odor-2	2.0E+03	116.96	100	Cancer Risk
METHYLNAPHTHALENE, 2-	0.5	0.66	14c			1000	Non-Odor	1.3E+03		1000	Ceiling
NAPHTHALENE	0.5	0.66	14c	0.98	8.20E-02	100	Non-Odor	1.3E+03		100	Ceiling
NICKEL	30	3	14d			1000	Non-Odor	3.1E+02		300	Noncancer Risk
PENTACHLOROPHENOL		3.3	14c		1.10E-04	1000	Non-Odor	9.6E+02	6.87	7	Cancer Risk
PHENANTHRENE	0.5	0.66	14c	2.40E-03	9.60E-04	1000	Non-Odor	1.0E+03		1000	Ceiling
PHENOL		0.66	14c	8.75	3.50E-01	500	Odor-2	1.1E+04		500	Ceiling
POLYCHLORINATED BIPHENYLS (PCBs)		0.04355	14b		NA	1000	Non-Odor	2.2E-01	0.2	2	* Sludge Stnd
PYRENE	0.5	0.66	14c		2.50E-06	1000	Non-Odor	6.8E+02		700	Noncancer Risk
SELENIUM		15	14d		NA	1000	Non-Odor	3.2E+02		300	Noncancer Risk
SILVER		1.4	14d			1000	Non-Odor	9.8E+01		100	Noncancer Risk
STYRENE		0.005	14a	16.67	5	500	Odor-2	4.5E+03	17.83	20	Cancer Risk

--------------- file: TXINF5-2.wk1, 4/20/94 --

TABLE 5-2

METHOD 2 DIRECT CONTACT S-1 DERIVATION 310 CMR 40.0985(6) — OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING	Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	Method 2, Direct Contact SOIL S-1 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
TETRACHLOROETHANE, 1,1,1,2-		0.005	14a		10	100	Volatility	1.4E+02	3.62	4	Cancer Risk
TETRACHLOROETHANE, 1,1,2,2-		0.005	14a	2.67	4	500	Odor-2		0.47	0.5	Cancer Risk
TETRACHLOROETHYLENE		0.005	14a	4.06	19	500	Odor-2	3.4E+02	168.69	200	Cancer Risk
THALLIUM		8	14d			1000	Non-Odor	4.1E+00		8	PQL
TOLUENE		0.005	14a	3.50	28	500	Odor-2	6.1E+03		500	Ceiling
TOTAL PETROLEUM HYDROCARBONS						1000	Non-Odor			500	* Default
TRICHLOROBENZENE, 1,2,4-		0.66	14c			1000	Non-Odor	3.7E+02		400	Noncancer Risk
TRICHLOROETHANE, 1,1,1-		0.005	14a	0.83	100	100	Volatility	3.0E+03		100	Ceiling
TRICHLOROETHANE, 1,1,2-		0.005	14a		25	100	Volatility	2.5E+01	2.28	2	Cancer Risk
TRICHLOROETHYLENE		0.005	14a	0.01	77	100	Volatility	6.7E+01	79.74	70	Noncancer Risk
TRICHLOROPHENOL, 2,4,5-		0.66	14c			1000	Non-Odor	1.9E+03		1000	Ceiling
TRICHLOROPHENOL 2,4,6-		0.66	14c			1000	Non-Odor		39.39	40	Cancer Risk
VINYL CHLORIDE		0.01	14a	0.86	2580	100	Volatility	3.4E+01	0.29	0.3	Cancer Risk
XYLENES (Mixed Isomers)		0.005	14a	60.00	6	500	Odor-2	6.1E+04		500	Ceiling
ZINC	110	0.4	14d			1000	Non-Odor	1.6E+04		2500	* Sludge Stnd

5.1.5 Soil Category S - 2

The Soil Category S-2 standards are based upon a an exposure scenario in which the potential receptor may come into contact with the contaminated soil in a work environment or in a passive recreational setting.

For both cancer and non-cancer health effects, the receptor of concern is worker (age 18 - 45 years) who comes into contact with soil as part of their employment. This evaluation considered passive recreational exposures to children and found that, given the exposure assumptions employed, the worker scenario described here is protective of those exposures.

FREQUENCY OF EXPOSURE:

* **The adult worker is <u>not</u> assumed to come into contact with the soil during the winter months (November through March) due to weather conditions (particularly frozen ground).**

* **During spring and summer months, the worker is assumed to come into contact with the material on a daily basis as part of their employment (5 days/week), less 30 additional days to account for alternative activities not involving the soil, vacations and inclement weather.**

INTENSITY OF EXPOSURE:

* **Adults (age 18 to 45 years) are assumed to ingest 50 mg of soil per day exposed.**

* **It is assumed that the hands, forearms, lower legs and feet of the receptor are exposed to the soil.**

BODY WEIGHT:

* **Typical (median) age-specific body weights were employed.**

The derivations of the Category S-2 soil ingestion and soil contact rates are given in Appendix B. Table 5.3 lists the S-2 Method 2 Direct Contact soil standards, and includes the calculated risk-based concentrations, background values, Odor Indices, vapor pressures, and Practical Quantitation Limits used to determine the S-2 Method 2 Direct Contact soil standards. The last column indicates the ultimate basis of the standard. Note that the derivation of the Category S-2 Method 1 Standards uses this information in combination with leaching considerations, as described in Section 5.2.

TABLE 5.3

TABLE 5-3

METHOD 2 DIRECT CONTACT
S-2 DERIVATION
310 CMR 40.0985(6)

OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING	Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	Method 2, Direct Contact SOIL S-2 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
ACENAPHTHENE	0.5	0.66	14c			2500	Non-Odor	3.6E+03		2500	Ceiling
ACENAPHTHYLENE	0.5	0.66	14c		2.90E-02	2500	Non-Odor	2.7E+03		2500	Ceiling
ACETONE		0.1	14a	20.77	270	1000	Odor-2	1.1E+04		1000	Ceiling
ALDRIN		0.00268	14b	5.87E-06	2.30E-05	2500	Non-Odor	1.5E+00	0.04	0.04	Cancer Risk
ANTHRACENE	0.5	0.66	14c		1.70E-05	2500	Non-Odor	1.3E+04		2500	Ceiling
ANTIMONY		6.4	14d			2500	Non-Odor	4.4E+01		40	Noncancer Risk
ARSENIC	32	10.6	14d			2500	Non-Odor	8.0E+01	2.08	30	Background
BENZENE		0.005	14a	63.33	95	1000	Odor-2	6.6E+02	62.88	60	Cancer Risk
BENZO(a)ANTHRACENE	0.5	0.66	14c		5.00E-09	2500	Non-Odor	2.7E+03	0.11	0.7	PQL
BENZO(a)PYRENE	0.5	0.66	14c		5.00E-09	2500	Non-Odor	2.7E+03	0.11	0.7	PQL
BENZO(b)FLUORANTHENE	0.5	0.66	14c		NA	2500	Non-Odor	2.7E+03	0.11	0.7	PQL
BENZO(g,h,i)PERYLENE	0.5	0.66	14c		1.00E-10	2500	Non-Odor	2.7E+03		2500	Ceiling
BENZO(k)FLUORANTHENE	0.5	0.66	14c		9.59E-11	2500	Non-Odor	2.7E+03	0.11	0.7	PQL
BERYLLIUM		0.06	14d			2500	Non-Odor	1.3E+03	0.85	0.8	Cancer Risk
BIPHENYL, 1,1-		0.05	14c			2500	Non-Odor	6.6E+03		2500	Ceiling
BIS(2-CHLOROETHYL)ETHER		0.66	14c	14.49	7.10E-01	1000	Odor-2		0.16	0.7	PQL
BIS(2-CHLOROISOPROPYL)ETHER		0.66	14c	2.66	8.50E-01	1000	Odor-2	5.2E+02	2.56	3	Cancer Risk
BIS(2-ETHYLHEXYL)PHTHALATE		0.66	14c			2500	Non-Odor	6.7E+03	325.27	300	Cancer Risk
BROMODICHLOROMETHANE		0.005	14a		50	500	Volatility	2.2E+03	24.51	20	Cancer Risk
BROMOFORM		0.005	14a	4.31	5.6	1000	Odor-2	2.0E+03	192.37	200	Cancer Risk
BROMOMETHANE		0.01	14a	71.00	1420	1000	Odor-2	1.5E+02		200	Noncancer Risk
CADMIUM		0.8	14d			2500	Non-Odor	8.3E+01		80	Noncancer Risk
CARBON TETRACHLORIDE		0.005	14a	11.30	113	1000	Odor-2	7.7E+01	11.69	10	Cancer Risk
CHLORDANE		0.00938	14b	7.12E-05	1.00E-05	2500	Non-Odor	1.1E+01	2.00	2	Cancer Risk
CHLOROANILINE, p-		1.3	14c		1.50E-02	2500	Non-Odor	4.4E+02		400	Noncancer Risk
CHLOROBENZENE		0.005	14c	53.64	11.8	1000	Odor-2	2.2E+03		1000	Ceiling
CHLOROFORM		0.005	14a	1.88	160	1000	Odor-2	1.1E+03	249.14	200	Cancer Risk
CHLOROPHENOL, 2-		0.66	14c			2500	Non-Odor	2.4E+02		200	Noncancer Risk
CHROMIUM(III)		1.4	14d		NA	2500	Non-Odor	2.2E+05		2500	Ceiling
CHROMIUM(VI)	105		14h		NA	2500	Non-Odor	6.0E+02		600	Noncancer Risk
CHRYSENE	0.5	0.66	14c		6.30E-09	2500	Non-Odor	2.7E+03	0.11	0.7	PQL
CYANIDE		1	16	1068.97	620	500	Odor-1	8.2E+02		100	Noncancer Risk *
DIBENZO(a,h)ANTHRACENE	0.5	0.66	14c		1.00E-10	2500	Non-Odor	5.4E+03	0.23	0.7	PQL
DIBROMOCHLOROMETHANE		0.005	14a		76	500	Volatility	2.2E+03	18.09	20	Cancer Risk
DICHLOROBENZENE, 1,2- (o-DCB)		0.66	14c	0.03	1.5	500	Volatility	9.9E+03		500	Ceiling
DICHLOROBENZENE, 1,3- (m-DCB)		0.66	14c	0.03	1.5	500	Volatility	9.9E+03		500	Ceiling(o-DCB)
DICHLOROBENZENE, 1,4- (p-DCB)		0.66	14c	10.00	1.8	1000	Odor-2		63.32	60	Cancer Risk
DICHLOROBENZIDINE, 3,3'-		1.3	14c		4.50E-09	2500	Non-Odor		0.72	1	PQL
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)		0.00737	14b		1.00E-06	2500	Non-Odor		3.45	3	Cancer Risk
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)		0.00268	14b		6.50E-06	2500	Non-Odor		2.44	2	Cancer Risk
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)		0.00804	14b		1.50E-07	2500	Non-Odor	3.0E+01	2.44	2	Cancer Risk
DICHLOROETHANE, 1,1-		0.005	14a	0.47	234	500	Volatility	8.5E+03		500	Ceiling
DICHLOROETHANE, 1,2-		0.005	14a	13.17	79	1000	Odor-2	2.2E+03	16.70	20	Cancer Risk
DICHLOROETHYLENE, 1,1-		0.005	14a	1.18	591	1000	Odor-2	9.9E+02	2.48	2	Cancer Risk

-------------- file: TXINF5-3.wk1, 4/20/94 --

TABLE 5-3

METHOD 2 DIRECT CONTACT
S-2 DERIVATION
310 CMR 40.0985(6)

OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING	Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	Method 2, Direct Contact SOIL S-2 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
DICHLOROETHYLENE, CIS-1,2-		0.005	14a		202	500	Volatility	1.1E+03		500	Ceiling
DICHLOROETHYLENE, TRANS-1,2-		0.005	14a	19.47	331	1000	Odor-2	2.2E+03		1000	Ceiling
DICHLOROPHENOL, 2,4-		0.66	14c	0.32	6.70E-02	2500	Non-Odor	9.4E+01		90	Noncancer Risk
DICHLOROPROPANE, 1,2-		0.005	14a	168.00	42	500	Odor-1		12.19	10	Cancer Risk
DICHLOROPROPENE, 1,3-		0.005	14a	43.00	43	1000	Odor-2	1.8E+01	4.61	5	Cancer Risk
DIELDRIN		0.00134	14b		1.80E-07	2500	Non-Odor	2.4E+00	0.04	0.04	Cancer Risk
DIETHYL PHTHALATE		0.66	14c			2500	Non-Odor	2.7E+05		2500	Ceiling
DIMETHYL PHTHALATE		0.66	14c			2500	Non-Odor	1.5E+05		2500	Ceiling
DIMETHYLPHENOL, 2,4-		0.66	14c			2500	Non-Odor	9.4E+02		900	Noncancer Risk
DINITROPHENOL, 2,4-		3.3	14c		NA	2500	Non-Odor	9.4E+01		90	Noncancer Risk
DINITROTOLUENE, 2,4-		0.66	14c		5.10E-03	2500	Non-Odor	1.8E+02	1.79	2	Cancer Risk
DIOXIN		1.0E-06	19		7.40E-10	2500	Non-Odor		0.00	6E-06	Cancer Risk
ENDOSULFAN		0.00938	14b		1.00E-05	2500	Non-Odor	3.0E+00		3	Noncancer Risk
ENDRIN		0.00402	14b		2.00E-07	2500	Non-Odor	1.5E+01		10	Noncancer Risk
ETHYLBENZENE		0.005	14a	4.35	10	1000	Odor-2	6.0E+03		1000	Ceiling
ETHYLENE DIBROMIDE		0.005	14a	0.46	12	500	Volatility	2.2E+00	0.02	0.02	Cancer Risk
FLUORANTHENE	0.5	0.66	14c		5.00E-06	2500	Non-Odor	2.4E+03		2000	Noncancer Risk
FLUORENE	0.5	0.66	14c			2500	Non-Odor	2.4E+03		2000	Noncancer Risk
HEPTACHLOR		0.00201	14b	0.01	3.00E-04	2500	Non-Odor	3.0E+01	0.18	0.2	Cancer Risk
HEPTACHLOR EPOXIDE		0.05561	14b	1.37E-04	2.60E-06	2500	Non-Odor	7.8E-01	0.09	0.09	Cancer Risk
HEXACHLOROBENZENE		0.66	14c		1.09E-05	2500	Non-Odor	7.1E+01	0.76	0.8	Cancer Risk
HEXACHLOROBUTADIENE		0.66	14c	1.17E-03	1.50E-01	2500	Non-Odor	1.2E+02	10.63	10	Cancer Risk
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)		0.00268	14b		9.40E-06	2500	Non-Odor	1.8E+01	0.64	0.6	Cancer Risk
HEXACHLOROETHANE		0.66	14b		4.00E-01	2500	Non-Odor	1.3E+01	12.78	10	Cancer Risk
INDENO(1,2,3-cd)PYRENE	0.5	0.66	14c		1.00E-09	2500	Non-Odor	2.7E+03	0.11	0.7	PQL
LEAD	69	8.4	14d			2500	Non-Odor	6.4E+02		600	Noncancer Risk
MERCURY	1	0.1	14i		1.20E-03	2500	Non-Odor	5.7E+01		60	Noncancer Risk
METHOXYCHLOR		0.11792	14b		1.40E-06	2500	Non-Odor	3.0E+02		300	Noncancer Risk
METHYL ETHYL KETONE		0.1	14a	9.09	100	1000	Odor-2	6.6E+04		1000	Ceiling
METHYL ISOBUTYL KETONE		0.05	14a	100.00	10	500	Odor-1	5.5E+03		500	Ceiling
METHYL MERCURY						2500	Non-Odor	1.8E+01		20	Noncancer Risk
METHYL TERT BUTYL ETHER		0.05	14f		245	500	Volatility	5.7E+02		500	Ceiling
METHYLENE CHLORIDE		0.005	14a	2.68	429	1000	Odor-2	6.6E+03	202.63	200	Cancer Risk
METHYLNAPHTHALENE, 2-	0.5	0.66	14c			2500	Non-Odor	4.4E+03		2500	Ceiling
NAPHTHALENE	0.5	0.66	14c	0.98	8.20E-02	2500	Non-Odor	4.4E+03		2500	Ceiling
NICKEL	30	3	14d			2500	Non-Odor	7.1E+02		700	Noncancer Risk
PENTACHLOROPHENOL		3.3	14c		1.10E-04	2500	Non-Odor	3.1E+03	11.69	10	Cancer Risk
PHENANTHRENE	0.5	0.66	14c	2.40E-03	9.60E-04	2500	Non-Odor	2.7E+03		2500	Ceiling
PHENOL		0.66	14c	8.75	3.50E-01	1000	Odor-2	2.8E+04		1000	Ceiling
POLYCHLORINATED BIPHENYLS (PCBs)		0.04355	14b		NA	2500	Non-Odor	7.9E-01	0.3	2	* Sludge Stnd
PYRENE	0.5	0.66	14c		2.50E-06	2500	Non-Odor	1.8E+03		2000	Noncancer Risk
SELENIUM		15	14d		NA	2500	Non-Odor	3.1E+03		2500	Ceiling
SILVER		1.4	14d			2500	Non-Odor	2.4E+02		200	Noncancer Risk
STYRENE		0.005	14a	16.67	5	1000	Odor-2	1.2E+04	27.64	30	Cancer Risk

------------- file: TXINF5-3.wk1, 4/20/94 --

Table 5.3, continued...

TABLE 5-3

METHOD 2 DIRECT CONTACT S-2 DERIVATION 310 CMR 40.0985(6) — OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING	Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	Method 2, Direct Contact SOIL S-2 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
TETRACHLOROETHANE, 1,1,1,2-		0.005	14a		10	500	Volatility	2.8E+02	4.94	5	Cancer Risk
TETRACHLOROETHANE, 1,1,2,2-		0.005	14a	2.67	4	1000	Odor-2		0.64	0.6	Cancer Risk
TETRACHLOROETHYLENE		0.005	14a	4.06	19	1000	Odor-2	1.1E+03	292.26	300	Cancer Risk
THALLIUM		8	14d			2500	Non-Odor	3.2E+01		30	Noncancer Risk
TOLUENE		0.005	14a	3.50	28	1000	Odor-2	1.9E+04		1000	Ceiling
TOTAL PETROLEUM HYDROCARBONS						2500	Non-Odor			2500	* Default
TRICHLOROBENZENE, 1,2,4-		0.66	14c			2500	Non-Odor	1.3E+03		1000	Noncancer Risk
TRICHLOROETHANE, 1,1,1-		0.005	14a	0.83	100	500	Volatility	9.9E+03		500	Ceiling
TRICHLOROETHANE, 1,1,2-		0.005	14a		25	500	Volatility	5.2E+01	3.14	3	Cancer Risk
TRICHLOROETHYLENE		0.005	14a	0.01	77	500	Volatility	2.2E+02	138.16	100	Cancer Risk
TRICHLOROPHENOL, 2,4,5-		0.66	14c			2500	Non-Odor	4.7E+03		2500	Ceiling
TRICHLOROPHENOL 2,4,6-		0.66	14c			2500	Non-Odor		59.23	60	Cancer Risk
VINYL CHLORIDE		0.01	14a	0.86	2580	500	Volatility	1.1E+02	0.50	0.5	Cancer Risk
XYLENES (Mixed Isomers)		0.005	14a	60.00	6	1000	Odor-2	1.9E+05		1000	Ceiling
ZINC	110	0.4	14d			2500	Non-Odor	1.0E+05		2500	Ceiling

5.1.6 Soil Category S - 3

The Soil Category S-3 standards are based upon a an exposure scenario in which the potential receptor may come into contact with the contaminated soil during a short but intense exposure, such as excavation work.

For non-cancer effects, it is assumed that the exposure occurs over a period of 3 months, but for carcinogenic effects it was felt that such a short exposure duration was beyond the limits of the cancer risk model to estimate risks. As a result, a 7 year exposure was used to evaluate potential cancer risk to the excavation/construction worker.

FREQUENCY OF EXPOSURE:

* **The adult worker is <u>not</u> assumed to come into contact with the soil during the winter months (November through March) due to weather conditions (particularly frozen ground).**

* **For non-cancer effects, the worker is assumed to come into contact with the material on a daily basis during the summer (5 days/week) as part of continuous excavation or construction work. The exposure is assumed to occur during the 92 days of June, July and August.**

* **For cancer risk-based concentrations, the worker is assumed to be exposed in a manner similar to the worker described for the S-2 standards (5 days/week during the spring and summer months) but for only 7 years duration.**

INTENSITY OF EXPOSURE:

* **Adults (age 18 to 45 years) are assumed to ingest 50 mg of soil per day exposed.**

* **It is assumed that the hands, forearms, lower legs and feet of the child (1 to 18 years) are exposed to the soil.**

BODY WEIGHT:

* **Typical (median) age-specific body weights were employed.**

The derivation of the S-3 soil ingestion and soil contact rates are given in Appendix C. The 3 month exposures calculated for the non-cancer risk-based concentrations are considered to be "subchronic" in nature, and the subchronic Reference Dose was used in the standard development process, when available. When the subchronic RfD was not available, the chronic RfD was used in its place, an assumption which is conservative (health protective) in nature. As a result of this necessary, conservative practice, an inconsistency developed where concentrations derived for the subchronic S-3 exposure were less than (approximately a factor of 2) the allowable chronic exposure identified for the S-2 standards. (In other words, you could work in the soil for 27 years, but you couldn't spend 3 months working in it.) In these limited number of cases, the S-3 standard was set equal to the S-2 standard.

Table 5.4 lists the S-3 Method 2 Direct Contact soil standards, and includes the calculated risk-based concentrations, background values, Odor Indices, vapor pressures, and Practical Quantitation Limits used to determine the S-3 Method 2 Direct Contact soil standards. The last column indicates the ultimate basis of the standard. Note that the derivation of the Category S-3 Method 1 Standards uses this information in combination with leaching considerations, as described in Section 5.2.

TABLE 5.4

TABLE 5-4

METHOD 2 DIRECT CONTACT S-3 DERIVATION 310 CMR 40.0985(6) ----------------- OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING	Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	Method 2, Direct Contact SOIL S-3 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
ACENAPHTHENE	0.5	0.66	14c			5000	Non-Odor	1.7E+04		5000	Ceiling
ACENAPHTHYLENE	0.5	0.66	14c		2.90E-02	5000	Non-Odor	1.2E+03		2500	from S-2
ACETONE		0.1	14a	20.77	270	2500	Odor-2	5.2E+04		2500	Ceiling
ALDRIN		0.00268	14b	5.87E-06	2.30E-05	5000	Non-Odor	6.9E-01	0.15	0.1	Cancer Risk
ANTHRACENE	0.5	0.66	14c		1.70E-05	5000	Non-Odor	6.0E+04		5000	Ceiling
ANTIMONY		6.4	14d			5000	Non-Odor	2.1E+01		40	from S-2
ARSENIC	32	10.6	14d			5000	Non-Odor	3.7E+01	7.72	30	Background
BENZENE		0.005	14a	63.33	95	2500	Odor-2	3.1E+03	231.43	200	Cancer Risk
BENZO(a)ANTHRACENE	0.5	0.66	14c		5.00E-09	5000	Non-Odor	1.2E+03	0.42	0.7	PQL
BENZO(a)PYRENE	0.5	0.66	14c		5.00E-09	5000	Non-Odor	1.2E+03	0.42	0.7	PQL
BENZO(b)FLUORANTHENE	0.5	0.66	14c		NA	5000	Non-Odor	1.2E+03	0.42	0.7	PQL
BENZO(g,h,i)PERYLENE	0.5	0.66	14c		1.00E-10	5000	Non-Odor	1.2E+03		2500	from S-2
BENZO(k)FLUORANTHENE	0.5	0.66	14c		9.59E-11	5000	Non-Odor	1.2E+03	0.42	0.7	PQL
BERYLLIUM		0.06	14d			5000	Non-Odor	6.2E+02	3.14	3	Cancer Risk
BIPHENYL, 1,1-		0.05	14c			5000	Non-Odor	3.1E+03		3000	Noncancer Risk
BIS(2-CHLOROETHYL)ETHER		0.66	14c	14.49	7.10E-01	2500	Odor-2		0.59	0.7	PQL
BIS(2-CHLOROISOPROPYL)ETHER		0.66	14c	2.66	8.50E-01	2500	Odor-2	2.4E+02	9.34	9	Cancer Risk
BIS(2-ETHYLHEXYL)PHTHALATE		0.66	14c			5000	Non-Odor	3.1E+03	1210.65	1000	Cancer Risk
BROMODICHLOROMETHANE		0.005	14a		50	500	Volatility	1.0E+03	90.11	90	Cancer Risk
BROMOFORM		0.005	14a	4.31	5.6	2500	Odor-2	9.5E+03	707.16	700	Cancer Risk
BROMOMETHANE		0.01	14a	71.00	1420	2500	Odor-2	7.2E+02		700	Noncancer Risk
CADMIUM		0.8	14d			5000	Non-Odor	1.9E+01		80	from S-2
CARBON TETRACHLORIDE		0.005	14a	11.30	113	2500	Odor-2	3.6E+02	42.97	40	Cancer Risk
CHLORDANE		0.00938	14b	7.12E-05	1.00E-05	5000	Non-Odor	5.3E+00	7.40	5	Noncancer Risk
CHLOROANILINE, p-		1.3	14c		1.50E-02	5000	Non-Odor	2.1E+02		400	from S-2
CHLOROBENZENE		0.005	14c	53.64	11.8	2500	Odor-2	1.0E+04		2500	Ceiling
CHLOROFORM		0.005	14a	1.88	160	2500	Odor-2	5.2E+02	915.83	500	Noncancer Risk
CHLOROPHENOL, 2-		0.66	14c			5000	Non-Odor	1.1E+03		1000	Noncancer Risk
CHROMIUM(III)		1.4	14d		NA	5000	Non-Odor	1.0E+05		5000	Ceiling
CHROMIUM(VI)	105		14h		NA	5000	Non-Odor	1.1E+03		1000	Noncancer Risk
CHRYSENE	0.5	0.66	14c		6.30E-09	5000	Non-Odor	1.2E+03	0.42	0.7	PQL
CYANIDE		1	16	1068.97	620	1000	Odor-1	3.9E+02		400	Noncancer Risk
DIBENZO(a,h)ANTHRACENE	0.5	0.66	14c		1.00E-10	5000	Non-Odor	2.5E+03	0.84	0.8	Cancer Risk
DIBROMOCHLOROMETHANE		0.005	14a		76	500	Volatility	1.0E+04	66.51	70	Cancer Risk
DICHLOROBENZENE, 1,2- (o-DCB)		0.66	14c	0.03	1.5	500	Volatility	4.6E+04		500	from S-2
DICHLOROBENZENE, 1,3- (m-DCB)		0.66	14c	0.03	1.5	500	Volatility	4.6E+04		500	from S-2(o-DCB)
DICHLOROBENZENE, 1,4- (p-DCB)		0.66	14c	10.00	1.8	2500	Odor-2	4.6E+04	232.77	200	Cancer Risk
DICHLOROBENZIDINE, 3,3'-		1.3	14c		4.50E-09	5000	Non-Odor		2.65	3	Cancer Risk
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)		0.00737	14b		1.00E-06	5000	Non-Odor		12.66	10	Cancer Risk
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)		0.00268	14b		6.50E-06	5000	Non-Odor		8.94	9	Cancer Risk
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)		0.00804	14b		1.50E-07	5000	Non-Odor	1.4E+01	8.94	9	Cancer Risk
DICHLOROETHANE, 1,1-		0.005	14a	0.47	234	500	Volatility	4.0E+04		500	from S-2
DICHLOROETHANE, 1,2-		0.005	14a	13.17	79	2500	Odor-2	1.0E+04	61.39	60	Cancer Risk
DICHLOROETHYLENE, 1,1-		0.005	14a	1.18	591	2500	Odor-2	4.6E+02	9.13	9	Cancer Risk

--------------- file: TXINF5-4.wk1, 4/20/94 --

TABLE 5-4

METHOD 2 DIRECT CONTACT S-3 DERIVATION 310 CMR 40.0985(6) OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING	Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	Method 2, Direct Contact SOIL S-3 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
DICHLOROETHYLENE, CIS-1,2-		0.005	14a		202	500	Volatility	5.2E+03		500	from S-2
DICHLOROETHYLENE, TRANS-1,2-		0.005	14a	19.47	331	2500	Odor-2	1.0E+04		2500	Ceiling
DICHLOROPHENOL, 2,4-		0.66	14c	0.32	6.70E-02	5000	Non-Odor	4.4E+01		90	from S-2
DICHLOROPROPANE, 1,2-		0.005	14a	168.00	42	1000	Odor-1		44.70	40	Cancer Risk
DICHLOROPROPENE, 1,3-		0.005	14a	43.00	43	2500	Odor-2	8.4E+01	16.89	20	Cancer Risk
DIELDRIN		0.00134	14b		1.80E-07	5000	Non-Odor	1.1E+00	0.15	0.2	Cancer Risk
DIETHYL PHTHALATE		0.66	14c			5000	Non-Odor	1.3E+06		5000	Ceiling
DIMETHYL PHTHALATE		0.66	14c			5000	Non-Odor	6.9E+04		5000	Ceiling
DIMETHYLPHENOL, 2,4-		0.66	14c			5000	Non-Odor	4.4E+03		4000	Noncancer Risk
DINITROPHENOL, 2,4-		3.3	14c		NA	5000	Non-Odor	4.4E+01		90	from S-2
DINITROTOLUENE, 2,4-		0.66	14c		5.10E-03	5000	Non-Odor	8.2E+01	6.57	7	Cancer Risk
DIOXIN		1.0E-06	19		7.40E-10	5000	Non-Odor		0.00	2E-05	Cancer Risk
ENDOSULFAN		0.00938	14b		1.00E-05	5000	Non-Odor	5.6E+00		6	Noncancer Risk
ENDRIN		0.00402	14b		2.00E-07	5000	Non-Odor	6.9E+00		10	from S-2
ETHYLBENZENE		0.005	14a	4.35	10	2500	Odor-2	2.8E+04		2500	Ceiling
ETHYLENE DIBROMIDE		0.005	14a	0.46	12	500	Volatility	1.0E+01	0.07	0.07	Cancer Risk
FLUORANTHENE	0.5	0.66	14c		5.00E-06	5000	Non-Odor	1.1E+04		5000	Ceiling
FLUORENE	0.5	0.66	14c			5000	Non-Odor	1.1E+04		5000	Ceiling
HEPTACHLOR		0.00201	14b	0.01	3.00E-04	5000	Non-Odor	1.4E+01	0.68	0.7	Cancer Risk
HEPTACHLOR EPOXIDE		0.05561	14b	1.37E-04	2.60E-06	5000	Non-Odor	3.6E-01	0.33	0.3	Cancer Risk
HEXACHLOROBENZENE		0.66	14c		1.09E-05	5000	Non-Odor	3.3E+01	2.79	3	Cancer Risk
HEXACHLOROBUTADIENE		0.66	14c	1.17E-03	1.50E-01	5000	Non-Odor	5.6E+01	38.97	40	Cancer Risk
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)		0.00268	14b		9.40E-06	5000	Non-Odor	8.4E+01	2.34	2	Cancer Risk
HEXACHLOROETHANE		0.66	14b		4.00E-01	5000	Non-Odor	6.0E+01	46.72	50	Cancer Risk
INDENO(1,2,3-cd)PYRENE	0.5	0.66	14c		1.00E-09	5000	Non-Odor	1.2E+03	0.42	0.7	PQL
LEAD	69	8.4	14d			5000	Non-Odor	2.9E+02		600	from S-2
MERCURY	1	0.1	14i		1.20E-03	5000	Non-Odor	2.7E+01		60	from S-2
METHOXYCHLOR		0.11792	14b		1.40E-06	5000	Non-Odor	1.4E+02		300	from S-2
METHYL ETHYL KETONE		0.1	14a	9.09	100	2500	Odor-2	2.6E+04		2500	Ceiling
METHYL ISOBUTYL KETONE		0.05	14a	100.00	10	1000	Odor-1	2.6E+04		1000	Ceiling
METHYL MERCURY						5000	Non-Odor	8.4E+00		20	from S-2
METHYL TERT BUTYL ETHER		0.05	14f		245	500	Volatility	2.7E+03		500	from S-2
METHYLENE CHLORIDE		0.005	14a	2.68	429	2500	Odor-2	3.1E+03	744.88	700	Cancer Risk
METHYLNAPHTHALENE, 2-	0.5	0.66	14c			5000	Non-Odor	2.1E+03		2500	from S-2
NAPHTHALENE	0.5	0.66	14c	0.98	8.20E-02	5000	Non-Odor	2.1E+03		2500	from S-2
NICKEL	30	3	14d			5000	Non-Odor	3.3E+02		700	from S-2
PENTACHLOROPHENOL		3.3	14c		1.10E-04	5000	Non-Odor	1.4E+03	42.96	40	Cancer Risk
PHENANTHRENE	0.5	0.66	14c	2.40E-03	9.60E-04	5000	Non-Odor	1.2E+03		2500	from S-2
PHENOL		0.66	14c	8.75	3.50E-01	2500	Odor-2	1.3E+04		2500	Ceiling
POLYCHLORINATED BIPHENYLS (PCBs)		0.04355	14b		NA	5000	Non-Odor	3.7E-01	1.0	2	Sludge Stnd
PYRENE	0.5	0.66	14c		2.50E-06	5000	Non-Odor	8.4E+03		5000	Ceiling
SELENIUM		15	14d		NA	5000	Non-Odor	1.4E+03		2500	from S-2
SILVER		1.4	14d			5000	Non-Odor	1.1E+02		200	from S-2
STYRENE		0.005	14a	16.67	5	2500	Odor-2	5.6E+04	101.32	100	Cancer Risk

--------------- file: TXINF5-4.wk1, 4/20/94 ---------------

TABLE 5-4

METHOD 2 DIRECT CONTACT S-3 DERIVATION 310 CMR 40.0985(6) ------------------ OIL AND/OR HAZARDOUS MATERIAL	SOIL BACK-GROUND mg/kg	SOIL PQL mg/kg	REF	ODOR INDEX	VAPOR PRESSURE Torr @ 20-30 C	CEILING	Ceiling Basis	Noncancer Risk-Based Concen. 0.2 mg/kg	Cancer Risk-Based Concen. 1E-06 mg/kg	Method 2, Direct Contact SOIL S-3 STANDARD 310 CMR 40.0985(6) mg/kg	Basis
TETRACHLOROETHANE, 1,1,1,2-		0.005	14a		10	500	Volatility	1.3E+02	18.07	20	Cancer Risk
TETRACHLOROETHANE, 1,1,2,2-		0.005	14a	2.67	4	2500	Odor-2		2.35	2	Cancer Risk
TETRACHLOROETHYLENE		0.005	14a	4.06	19	2500	Odor-2	5.2E+03	1074.34	1000	Cancer Risk
THALLIUM		8	14d			5000	Non-Odor	1.5E+02		100	Noncancer Risk
TOLUENE		0.005	14a	3.50	28	2500	Odor-2	8.8E+04		2500	Ceiling
TOTAL PETROLEUM HYDROCARBONS						5000	Non-Odor			5000	* Default
TRICHLOROBENZENE, 1,2,4-		0.66	14c			5000	Non-Odor	6.2E+02		1000	from S-2
TRICHLOROETHANE, 1,1,1-		0.005	14a	0.83	100	500	Volatility	4.6E+04		500	from S-2
TRICHLOROETHANE, 1,1,2-		0.005	14a		25	500	Volatility	2.4E+02	11.47	10	Cancer Risk
TRICHLOROETHYLENE		0.005	14a	0.01	77	500	Volatility	1.0E+03	507.87	500	Ceiling
TRICHLOROPHENOL, 2,4,5-		0.66	14c			5000	Non-Odor	2.2E+04		5000	Ceiling
TRICHLOROPHENOL 2,4,6-		0.66	14c			5000	Non-Odor		216.97	200	Cancer Risk
VINYL CHLORIDE		0.01	14a	0.86	2580	500	Volatility	5.2E+01	1.85	2	Cancer Risk
XYLENES (Mixed Isomers)		0.005	14a	60.00	6	2500	Odor-2	1.8E+05		2500	Ceiling
ZINC	110	0.4	14d			5000	Non-Odor	4.7E+04		5000	Ceiling

5.2 SOIL LEACHING TO GROUNDWATER

The MCP Method 1 Soil Standards are <u>not</u> based solely upon human health risk associated with direct contact exposures to the soil. Consideration is also being given to the potential for a chemical to leach from the soil and contaminate the underlying aquifer. It was the intent of the Department to promulgate soil standards which will not result in significant impacts to the groundwater. Such a philosophy is consistent with the definition of a permanent solution in the MCP.

The soil-to-groundwater migration is dependent upon a large number of factors, including: soil concentration of the contaminant, the mass and volume of contamination and its vertical location in the soil, groundwater flow, the precipitation which percolated through the contaminated soil, biodegradation, volatilization, physical characteristics of the soil, meteorological conditions, and physical characteristics of the chemical (including partitioning coefficients, solubility, etc...).

There are numerous soil leaching models available which consider these factors to establish a concentration of a chemical in soil protective of a specified groundwater concentration. These models vary in sophistication, and in some cases generalizations have been made simplify the approach. **The Department has employed the *SESOIL* model to develop such concentrations.** Appendix F describes the use of the *SESOIL* model to develop the dilution/attenuation factors used in this section.

By necessity the sophisticated models are dependent upon the parameters chosen to describe the "typical site" which is entered into the model. The analysis conducted by the Department makes such assumptions, with the understanding that site-specific soil-leaching models may be used using Risk Characterization Method 2 or 3.

5.2.1 Leaching Equations

The leaching-based soil concentrations are calculated using the equations

$$DAF_{OHM} = (6207 \, x \, H_{OHM}) + (0.166 \, x \, Koc_{OHM}) \qquad \textbf{(11)}$$

and

$$[OHM]_{soil} = DAF_{OHM} \; x \; [OHM]_{gw} \; x \; C \qquad \textbf{(12)}$$

Where:

DAF_{ohm} =	The Dilution/Attenuation Factor calculated for the oil or hazardous material
H_{ohm} =	The Henry's Law Constant for the oil or hazardous material, in units of atm-m^3/mol
Koc_{ohm} =	The organic carbon partition coefficient for the oil or hazardous material, in units: ml/g
$[OHM]_{soil}$ =	The leaching-based soil concentration, in units: mg/kg.
$[OHM]_{gw}$ =	The target groundwater concentration of the oil or hazardous material. In units of μg/liter.
C =	Units Conversion factor, 0.001 mg/μg.

The coefficients used to calculated the Dilution/Attenuation Factor are developed in Appendix F. The target groundwater concentrations used are the MCP Method 1 Groundwater Standards GW-1, GW-2 and GW-3. Thus for a given oil or hazardous material, leaching-based

concentrations were developed for nine combinations of soil:groundwater categories. These combinations are shown in Figure 5-3.

FIGURE 5-3
Combinations of Soil:Groundwater Leaching-Based Standards

	GW - 1	GW - 2	GW - 3
S - 1	S-1/GW-1	S-1/GW-2	S-1/GW-3
S - 2	S-2/GW-1	S-2/GW-2	S-2/GW-3
S - 3	S-3/GW-1	S-3/GW-2	S-3/GW-3

5.2.2. Derivation of Leaching-Based Standards

Figure 5-2 described the general methodology for the consideration of the leaching-based concentrations in the development of the Method 1 standards. The leaching-based concentrations are compared to the risk-based concentrations calculated for each exposure scenario, and the lowest of these values is carried through the standard development process (see methodology, Section 5.1.1).

Table 5.5 contains the leaching-based soil concentrations for each of the target groundwater concentrations (by Groundwater Category) and the MCP Method 1 Soil Standards for each combination of soil and groundwater category. It is clear that for many compounds, the most sensitive factor in the development of Method 1 Standards is the potential for leaching to groundwater.

5.3 UPPER CONCENTRATION LIMITS

The Upper Concentration Limits (UCLs) in Soil (310 CMR 40.0996(4)) are applicable when risk characterization or Method 3 is used to evaluate the potential risk of harm to health, public welfare and the environment. ***The Upper Concentration Limits (UCLs) are not used in risk characterization Methods 1*** as sites meeting the Method 1 Standards meet the Upper Concentration Limits, by definition.

The categorization scheme devised to determine the "current and foreseeable use(s)" of the soil essentially clarifies why the Department is concerned about contamination in soil and related human and/or ecological impacts.

Our ability to comprehensively describe (qualitatively or quantitatively) potential impacts is limited, however, particularly impacts which may only become evident in the future. The MCP defines areas of particular interest based upon human exposure potential and allows some flexibility to establish alternative cleanup requirements using risk assessment in Methods 2 and 3. The Upper Concentration Limits identify contamination which may pose a significant risk of harm to public welfare and the environment in the future, and to minimize the incremental

contributions to anthropogenic background. The Department does not endorse the general degradation of the soil.

The revised MCP contains several features intended to provide protection to all soil, including: (a) the requirement to use the best remedial action management approaches (BRAMA) to characterize a site (310 CMR 40.0191); (b) the requirement to eliminate all continuing sources of release to the environment (310 CMR 40.1003(5)); and (c) the list of Upper Concentration Limits applicable to all soil as public welfare environmental resource standards (310 CMR 40.0994(3) and 310 CMR 40.0995(5)).

A disposal site may qualify for a Class C Response Action Outcome (RAO), even if the concentrations of oil or hazardous material remaining at the disposal site exceed the Upper Concentration Limits. An exceedance of these standards is interpreted to indicate significant risk of harm to public welfare and/or environmental resources in the future, and thus a Class C RAO may be appropriate if, for current conditions, a condition of no significant risk of harm to health, safety, public welfare and the environment exists or has been achieved.

The UCLs are simply 10 fold multiple of the highest exposure-related (S-1, S-2 or S-3) standard, capped at a maximum concentration of 10,000 μg/gram, or 1 %. The Upper Concentration Limits in Soil are listed in Table 1.1.

5.4 EXAMPLE 2

The multiple soil/groundwater combinations result in a somewhat complex system where the applicability of a given standard is dependent upon may factors. Figure 5-4 provides a second example (Figure 1-2 contains the first) of how the Method 1 soil and groundwater standards would be applied to a hypothetical disposal site.

TABLE 5.5

TABLE 5-5

METHOD 1 SOIL STANDARDS

OIL AND/OR HAZARDOUS MATERIAL	LEACHING-BASED SOIL CONCENTRATIONS For Target Ground-water Categories GW-1 mg/kg	GW-2 mg/kg	GW-3 mg/kg	Method 1 S-1 Soil Standards NOT ROUNDED S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	Method 1 S-2 Soil Standards NOT ROUNDED S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW-3 mg/kg	Method 1 S-3 Soil Standards NOT ROUNDED S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-3/GW-3 mg/kg
ACENAPHTHENE	15		1530	15	1000	1000	15	2500	1530	15	5000	1530
ACENAPHTHYLENE	127		848	100	100	100	127	2500	848	127	2500	848
ACETONE	3	58	58	3	58	58	3	58	58	3	58	58
ALDRIN	4	4	73	0.03	0.03	0.03	0.04	0.04	0.04	0.15	0.146	0.146
ANTHRACENE	1395		1395	1000	1000	1000	1395	2500	1395	1395	5000	1395
ANTIMONY				10	10	10	40	40	40	40	40	40
ARSENIC				30	30	30	30	30	30	30	30	30
BENZENE	10	96	335	0.2	30	30	0.24	60	60	0	96	200
BENZO(a)ANTHRACENE	7		166	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
BENZO(a)PYRENE	183		1826	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
BENZO(b)FLUORANTHENE	18		639	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
BENZO(g,h,i)PERYLENE	133		27	133	1000	27	133	2500	27	133	2500	27
BENZO(k)FLUORANTHENE	18		37	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
BERYLLIUM				0.40	0.40	0.40	0.8	0.8	0.8	3	3	3
BIPHENYL, 1,1-	1.0		10	1.0	1000	10	1.0	2500	10	1.0	3000	10
BIS(2-CHLOROETHYL)ETHER	0.07	0.2	109	0.66	0.66	0.70	0.66	0.66	0.66	0.66	0.66	0.66
BIS(2-CHLOROISOPROPYL)ETHER	0.3	4	541	0.66	2	2	0.66	3	3	0.66	4	9
BIS(2-ETHYLHEXYL)PHTHALATE	100	11620	498	100	100	100	100	300	300	100	1000	498
BROMODICHLOROMETHANE	0.1		1182	0.12	10	10	0.12	20	20	0.12	90	90
BROMOFORM	0.1	18	1118	0.11	18	100	0.11	18	200	0.11	18	700
BROMOMETHANE	12	3	61188	12	3	50	12	3	200	12	3	700
CADMIUM				30	30	30	80	80	80	80	80	80
CARBON TETRACHLORIDE	1.0	4	10003	1.0	4	7	1.0	4	10	1.0	4	40
CHLORDANE	36		14	1.0	1.0	1.0	2	2	2	5	5	5
CHLOROANILINE, p-	0.02		26	1.3	100	26	1.3	400	26	1.3	400	26
CHLOROBENZENE	8	79	40	8	79	40	8	79	40	8	79	40
CHLOROFORM	0.1	10	262	0.13	10	100	0.13	10	200	0.13	10	262
CHLOROPHENOL, 2-	0.006		23	0.7	100	23	0.7	200	23	0.7	1000	23
CHROMIUM (TOTAL)												
CHROMIUM (III)				1000	1000	1000	2500	2500	2500	5000	5000	5000
CHROMIUM (VI)				200	200	200	600	600	600	1000	1000	1000
CHRYSENE	7		100	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
CYANIDE	2E+06		117933	100	100	100	100	100	100	400	400	400
DIBENZO(a,h)ANTHRACENE	110		164	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8
DIBROMOCHLOROMETHANE	0.09		933	0.09	10	10	0.09	20	20	0.09	70	70
DICHLOROBENZENE, 1,2- (o-DCB)	177	2942	2354	100	100	100	177	500	500	177	500	500
DICHLOROBENZENE, 1,3- (m-DCB)	179	2985	2388	100	100	100	179	500	500	179	500	500
DICHLOROBENZENE, 1,4- (p-DCB)	2	9569	2552	2	40	40	2	60	60	2	200	200
DICHLOROBENZIDINE, 3,3'-	21		516	1.0	1.0	1.0	1.3	1.3	1.3	3	3	3
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)	19		773	2	2	2	3	3	3	10	10	10
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)	75		14492	2	2	2	2	2	2	9	9	9
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)	12		12	2	2	2	2	2	2	9	9	9
DICHLOROETHANE, 1,1-	3	390	2169	3	100	100	3	390	500	3	390	500
DICHLOROETHANE, 1,2-	0.05	0.2	456	0.05	0.18	10	0.05	0.18	20	0.05	0.18	60

-------------------- file: TXINF5-5.wk1, 4/20/94 --------------------

Table 5.5, continued...

TABLE 5-5 METHOD 1 SOIL STANDARDS OIL AND/OR HAZARDOUS MATERIAL	LEACHING-BASED SOIL CONCENTRATIONS For Target Ground-water Categories			Method 1 S-1 Soil Standards NOT ROUNDED			Method 1 S-2 Soil Standards NOT ROUNDED			Method 1 S-3 Soil Standards NOT ROUNDED		
	GW-1 mg/kg	GW-2 mg/kg	GW-3 mg/kg	S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW-3 mg/kg	S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-3/GW-3 mg/kg
DICHLOROETHYLENE, 1,1-	0.7	0.1	5160	0.7	0.10	1.0	0.7	0.10	2	0.7	0.10	9
DICHLOROETHYLENE, CIS-1,2-	2		1673	2	100	100	2	500	500	2	500	500
DICHLOROETHYLENE, TRANS-1,2-	4		2058	4	500	500	4	1000	1000	4	2500	2058
DICHLOROPHENOL, 2,4-	10		4001	10	40	40	10	90	90	10	90	90
DICHLOROPROPANE, 1,2-	0.1	0.2	758	0.13	0.23	8	0.13	0.23	10	0.13	0.23	40
DICHLOROPROPENE, 1,3-	0.01	0.1	52	0.01	0.13	3	0.01	0.13	5	0.01	0.13	20
DIELDRIN	0.1		0.1	0.03	0.03	0.03	0.04	0.04	0.04	0.12	0.15	0.12
DIETHYL PHTHALATE	141		0.7	141	1000	0.7	141	2500	0.7	141	5000	0.7
DIMETHYL PHTHALATE	26		0.02	26	1000	0.7	26	2500	0.7	26	5000	0.7
DIMETHYLPHENOL, 2,4-	0.06		12	0.7	400	12	0.7	900	12	0.7	4000	12
DINITROPHENOL, 2,4-	0.6		6	3	40	6	3	90	6	3	90	6
DINITROTOLUENE, 2,4-	0.2		15	0.7	1.0	1.0	0.7	2	2	0.7	7	7
DIOXIN	0.02		0.05	4E-06	4E-06	4E-06	6E-06	6E-06	6E-06	2E-05	2E-05	2E-05
ENDOSULFAN	0.2		0.05	0.18	1.0	0.05	0.18	3	0.05	0.18	6	0.05
ENDRIN	0.6		1.4	0.6	6	1.4	0.6	10	1.4	0.6	10	1.4
ETHYLBENZENE	82	3502	467	82	500	467	82	1000	467	82	2500	467
ETHYLENE DIBROMIDE	2E-04	0.04	574	0.005	0.010	0.010	0.01	0.02	0.02	0.01	0.04	0.07
FLUORANTHENE	631		631	631	900	631	631	2000	631	631	5000	631
FLUORENE	364		1213	364	900	900	364	2000	1213	364	5000	1213
HEPTACHLOR	1.5		4	0.10	0.10	0.10	0.18	0.18	0.18	0.7	0.7	0.7
HEPTACHLOR EPOXIDE	0.8		8	0.06	0.06	0.06	0.09	0.09	0.09	0.33	0.33	0.33
HEXACHLOROBENZENE	200		7983	0.7	0.7	0.7	0.8	0.8	0.8	3	3	3
HEXACHLOROBUTADIENE	3	3	448	3	3	7	3	3	10	3	3	40
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)	0.1		0.5	0.12	0.40	0.40	0.12	0.6	0.49	0.12	2	0.49
HEXACHLOROETHANE	27	34	16906	6	6	6	10	10	10	27	34	50
INDENO(1,2,3-cd)PYRENE	53		80	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
LEAD				300	300	300	600	600	600	600	600	600
MERCURY				10	10	10	60	60	60	60	60	60
METHOXYCHLOR	527		26	100	100	26	300	300	26	300	300	26
METHYL ETHYL KETONE	0.3	38	38	0.27	38	38	0.27	38	38	0.27	38	38
METHYL ISOBUTYL KETONE	0.5	68	68	0.48	68	68	0.48	68	68	0.48	68	68
METHYL MERCURY				7	7	7	20	20	20	20	20	20
METHYL TERT BUTYL ETHER	3	209	209	3	100	100	3	209	209	3	209	209
METHYLENE CHLORIDE	0.1	1063	1063	0.11	100	100	0.11	200	200	0.11	700	700
METHYLNAPHTHALENE, 2-	0.02	23	7	0.7	23	7	0.7	23	7	0.7	23	7
NAPHTHALENE	4	1327	1327	4	100	100	4	1327	1327	4	1327	1327
NICKEL				300	300	300	700	700	700	700	700	700
PENTACHLOROPHENOL	5		420	5	7	7	5	10	10	5	40	40
PHENANTHRENE	697		116	697	1000	116	697	2500	116	697	2500	116
PHENOL	61	757	454	61	500	454	61	757	454	61	757	454
POLYCHLORINATED BIPHENYLS	44		26	2	2	2	2	2	2	2	2	2
PYRENE	505		505	505	700	505	505	2000	505	505	5000	505
SELENIUM				300	300	300	2500	2500	2500	2500	2500	2500
SILVER				100	100	100	200	200	200	200	200	200

-------------------- file: TXINF5-5.wk1, 4/20/94 --

Table 5.5, continued...

TABLE 5-5 METHOD 1 SOIL STANDARDS	LEACHING-BASED SOIL CONCENTRATIONS For Target Ground-water Categories			Method 1 S-1 Soil Standards NOT ROUNDED			Method 1 S-2 Soil Standards NOT ROUNDED			Method 1 S-3 Soil Standards NOT ROUNDED		
OIL AND/OR HAZARDOUS MATERIAL	GW-1 mg/kg	GW-2 mg/kg	GW-3 mg/kg	S-1/GW-1 mg/kg	S-1/GW-2 mg/kg	S-1/GW-3 mg/kg	S-2/GW-1 mg/kg	S-2/GW-2 mg/kg	S-2/GW-3 mg/kg	S-3/GW-1 mg/kg	S-3/GW-2 mg/kg	S-3/GW-3 mg/kg
STYRENE	2	15	836	2	15	20	2	15	30	2	15	100
TETRACHLOROETHANE, 1,1,1,2-	0.4	0.5	3862	0.39	0.46	4	0.39	0.46	5	0.39	0.46	20
TETRACHLOROETHANE, 1,1,2,2-	0.02	0.2	199	0.02	0.20	0.5	0.02	0.20	0.6	0.02	0.20	2
TETRACHLOROETHYLENE	0.5	271	452	0.45	200	200	0.45	271	300	0.45	271	452
THALLIUM				8	8	8	30	30	30	100	100	100
TOLUENE	86	518	4314	86	500	500	86	518	1000	86	518	2500
TOTAL PETROLEUM HYDROCARBONS				500	500	500	2500	2500	2500	5000	5000	5000
TRICHLOROBENZENE, 1,2,4-	108	922	768	108	400	400	108	922	768	108	922	768
TRICHLOROETHANE, 1,1,1-	34	678	8472	34	100	100	34	500	500	34	500	500
TRICHLOROETHANE, 1,1,2-	0.3	1139	2847	0.28	2	2	0.28	3	3	0.28	10	10
TRICHLOROETHYLENE	0.4	23	1544	0.39	23	70	0.39	23	100	0.39	23	500
TRICHLOROPHENOL, 2,4,5-	3		2	3	1000	2	3	2500	2	3	5000	2
TRICHLOROPHENOL 2,4,6-	3	13281	3320	3	40	40	3	60	60	3	200	200
VINYL CHLORIDE	0.4	0.3	113	0.30	0.28	0.30	0.38	0.28	0.5	0.38	0.28	2
XYLENES	828	497	4142	500	497	500	828	497	1000	828	497	2500
ZINC				2500	2500	2500	2500	2500	2500	5000	5000	5000

FIGURE 5-4

EXAMPLE #2: *Based on the criteria in the MCP, the groundwater at the disposal site is determined to be drinking water (Category GW-1) and, like all groundwater, has the potential to eventually discharge to surface water (Category GW-3). The soil of concern is the top foot of soil in the backyard of a suburban residential location, and has been categorized as S-1. For each oil or hazardous material, the applicable standards (shaded below) under MCP Method 1 would be both the GW-1 and GW-3 concentrations in groundwater (µg/liter, or ppb) and both the lower of the S-1/GW-1 and the S-1/GW-3 concentrations in soil (µg/gram, or ppm). [Another way to say this is that the lower of the applicable groundwater standards and the lower of the applicable soil standards would be used.] In the regulations, these standards are located on Tables 1 and 2, respectively.*

If the Groundwater Category is:	GW-1	GW-2	GW-3

Table 1: 40.0974(2)

Then these Groundwater Standards apply AND the Soil Standards directly below them are potentially applicable: ->	GW-1 µg/liter	GW-2 µg/liter	GW-3 µg/liter

If the Soil Category is: ↓↓

Then these Soil Standards are applicable, depending upon the Groundwater Category:

Table 2: 40.0975(6)(a)

S-1	S-1/GW-1 µg/gram	S-1/GW-2 µg/gram	S-1/GW-3 µg/gram

Table 3: 40.0975(6)(b)

S-2	S-2/GW-1 µg/gram	S-2/GW-2 µg/gram	S-2/GW-3 µg/gram

Table 4: 40.0975(6)(c)

S-3	S-3/GW-1 µg/gram	S-3/GW-2 µg/gram	S-3/GW-3 µg/gram

6.0 REFERENCES

c.21E — Massachusetts Oil and Hazardous Material Release Prevention and Control Act, Massachusetts General Law Chapter 21E.

Ershow & Cantor (1989) — Total Water and Tapwater Intake In the United States: Population Base Estimates of Quantities and Sources, Ershow, A.G. and Cantor, K.P., Life Sciences Research Office, Federation of American Societies for Experimental Biology, Bethesda, MD (1989).

Hawley (1985) — Hawley, J.K. (1985) *Assessment of Health Risk from Exposure to Contaminated Soil*, **Risk Analysis** 5(4).

HEAST — Health Effects Assessment Summary Tables, U.S. Environmental Protection, Office of Research and Development, Office of Emergency and Remedial Response, Washington D.C. Published annually and updated periodically.

IRIS — Integrated Risk Information System, U.S. Environmental Protection Agency on-line database.

Johnson & Ettinger (1991) — Johnson, P.C. and Ettinger, R.A. (1991) *Heuristic Model for Predicting the Intrusion Rate of Contaminated Vapors into Buildings*, **Environmental Science and Technology** 25:1445-1452.

LaGoy (1987) — LaGoy, P.K. (1987) *Estimated Soil Ingestion Rates for Use in Risk Assessment*, **Risk Analysis** 7(3).

Little (1992) — Little, J.C., Daisey, J.M., and Nazaroff, W.W. (1992) *Transport of Subsurface Contaminants into Buildings*, **Environmental Science and Technology** 26(11):2058-2066.

MA DEQE (1985) — Assessment of Potential Human Exposure from Dermal and Oral Ingestion of Contaminated Soil, Barbara G. Callahan, Ph.D. (December, 1985).

MA DEQE (1989) — Guidance for Disposal Site Risk Characterization and Related Phase II Activities - In Support of the Massachusetts Contingency Plan, Massachusetts Department of Environmental Quality Engineering. [Policy No. WSC/ORS-141-89] (1989).

MA DEP (1990a) — Guide to the Regulation of Toxic Chemicals in Massachusetts Waters, Massachusetts Department of Environmental Protection. [Office of Research and Standards Publication No. 90-2] (1990).

MA DEP (1990b) The Chemical Health Effects Assessment Methodology (CHEM) and the Method to Derive Allowable Ambient Limits (AAL), Volumes I & II, Massachusetts Department of Environmental Protection [Office of Research and Standards Publication No. 90-1] (1990).

MA DEP (1990c) Background Documentation For The Development Of An "Available" Cyanide Benchmark Concentration, Massachusetts Department of Environmental Protection, Office of Research and Standards, EXTERNAL REVIEW DRAFT (1990).

MA DEP (1991) Development of Soil Advisory Levels, Technical Support Document, Massachusetts Department of Environmental Protection, Office of Research and Standards, **DRAFT** (October 1991).

MA DEP (1992a) Documentation for the Risk Assessment ShortForm, Residential Scenario, Massachusetts Department of Environmental Protection. [Policy No. WSC/ORS-142-92] (1992).

MA DEP (1992b) Draft Discussion Document - Groundwater Cleanup Standards at 21E Sites, Massachusetts Department of Environmental Protection (October 8, 1992).

MADEP (1993) Petroleum Policy: Development of Health Based Alternative to the TPH Parameter DRAFT, Massachusetts Department of Environmental Protection, Office of Research and Standards and ABB Environmental Services, Inc, Wakefield MA. February 1993.

MCP Massachusetts Contingency Plan, 310 CMR 40.000. The Massachusetts Department of Environmental Protection. Originally promulgated in October, 1988 and revised July 30, 1993.

Shah (1988) Shah, J.J. and Singh, H.B. (1988) *Distribution of Volatile Organic Chemicals in Outdoor and Indoor Air*, **Environmental Science and Technology** 22(12):1381-1388.

Stolwijk (1990) Stolwijk, J.A.J. (1990) *Assessment of Population Exposure and Carcinogenic Risk Posed By Volatile Organic Compounds in Indoor Air*, **Risk Analysis** 10(1):49-57.

USEPA (1989a) Risk Assessment Guidance for Superfund: Volume I -- Human Health Evaluation Manual (Part A), U.S. Environmental Protection Agency, Office of Emergency and Remedial Response [EPA 540/1-89/002] (December 1989).

USEPA (1989b) Exposure Factors Handbook, U.S. Environmental Protection Agency, Office of Health and Environmental Assessment [EPA/600/8-89/043] (March 1989).

USEPA (1991) Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors", U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response [OSWER Directive 9285.6-03] (1991).

APPENDIX A

DERIVATION OF SOIL S-1

NORMALIZED AVERAGE DAILY SOIL INGESTION RATE (NADSIR)

NORMALIZED AVERAGE DAILY SOIL/SKIN CONTACT RATE (NADSCR)

NORMALIZED <u>LIFETIME</u> AVERAGE DAILY SOIL INGESTION RATE (NLADSIR)

NORMALIZED <u>LIFETIME</u> AVERAGE DAILY SOIL/SKIN CONTACT RATE (NLADSCR)

APPENDIX A

DERIVATION OF SOIL S-1 EXPOSURE RATES

1. SOIL INGESTION RATES:

This section describes the development of the soil ingestion rates used to calculate the S-1 soil standards. These values are age specific and normalized to body weight. As a result of the detailed analysis, each age group experiences a slightly different exposure, and the calculated annual average daily soil ingestion rates range between approximately 20 to 60 mg of soil per day. The step-wise process followed in the calculation of the exposure rates is described below.

STEP 1: Ingestion of indoor dust is considered for young children, aged 1 to 6 years. It is assumed that each exposure event consists of the ingestion of the dust/soil covering the surface of one half of one finger. Table A-1 develops soil ingestion rates for these indoor exposures, and this information is used in Step 2.

TABLE A-1

INDOOR-ONLY SOIL INGESTION EXPOSURE

AGE	Skin Surface Area: 1/2 of One Finger[1]	Dust Adherence[2]	Fraction of Dust from Soil[3]	Frequency of Finger Mouthing Events[4]	Hours of Exposure per day	Soil Ingested - INDOOR ONLY[5]
years	cm^2/event	mg/cm^2		events/hour	hrs/day	mg soil/day
1 < 2	7.3	0.056	0.8	9	3	28.8
2 < 3	7.7	0.056	0.8	9	7	21.7
3 < 4	9.9	0.056	0.8	9	7	27.9
4 < 5	10.1	0.056	0.8	9	7	28.5
5 < 6	11.1	0.056	0.8	9	7	31.3

1 - The surface area of 1/2 of one finger is assumed to be approximately equal to 1/40 the surface area of both hands. The source of the Surface area information is described in more detail in Table A-5. This value is derived from that table: (Column 2 * Column 3 /100/40).

2 - Hawley, 1985; average dust covering indoor surfaces assumed to be the average dust covering finger.

3 - Hawley, 1985

4 - MA DEQE, 1985

5 - The mass of soil ingested as a result of finger mouthing activities. Example, age 1 < 2:

7.3 * 0.056 * 0.8 * 9 * 3 = 8.8 mg soil/day

STEP 2: An annual average daily soil intake is developed for each age group, as shown in Table A-2. This value is weighted to reflect the relative time spent outdoors where greater exposure to soil is expected. The resulting soil ingestion rates are then used in Step 3.

TABLE A-2

CALCULATION OF AGE-SPECIFIC SOIL INGESTION RATES

	SOIL INGESTION RATES * On days Exposed *		FREQUENCY OF EXPOSURE		ANNUAL AVERAGE 365 days
AGE	Indoor Exposure Only[1]	Indoor & Outdoor Exposure[2]	Indoors Only[3] Oct. -> April of 212 days	Indoors + Outdoors[4] May -> Sept. of 153 days	DAILY SOIL INGESTION RATE[5]
years	mg soil/d	mg soil/d	days	days	mg soil/d
< 1	0	0	0	0	0
1 < 2	8.8	100	212	44 + 109 = 153	47.0
2 < 3	21.7	100	212	44 + 109 = 153	54.5
3 < 4	27.9	100	212	44 + 109 = 153	58.1
4 < 5	28.5	100	212	44 + 109 = 153	58.5
5 < 6	31.3	100	212	44 + 109 = 153	60.1
6 < 7	0	50	0	44 + 109 = 153	21.0
7 < 8	0	50	0	44 + 109 = 153	21.0
8 < 9	0	50	0	44 + 109 = 153	21.0
9 < 10	0	50	0	44 + 109 = 153	21.0
10 < 11	0	50	0	44 + 109 = 153	21.0
11 < 12	0	50	0	44 + 109 = 153	21.0
12 < 13	0	50	0	44 + 109 = 153	21.0
13 < 14	0	50	0	44 + 109 = 153	21.0
14 < 15	0	50	0	44 + 109 = 153	21.0
15 < 16	0	50	0	44 + 109 = 153	21.0
16 < 17	0	50	0	44 + 109 = 153	21.0
17 < 18	0	50	0	44 + 109 = 153	21.0
18 < 25	0	50	0	44 + 109 = 153	21.0
25 < 30	0	50	0	44 + 109 = 153	21.0

1 - Indoor ONLY Exposures taken from Table A-1.

2 - Soil Ingestion Rate on days when BOTH Indoor & Outdoor exposures may occur taken from LaGoy (1987)

3 - 212 days is approximately 7 days/week from October through April. No outdoor exposure is assumed to occur during this period.

4 - 153 days approximates indoor exposures 2 days/week and outdoor exposures 5 days/week during this period.

5 - The average daily soil ingestion rate for this age group, adjusted for the frequency of exposure. Example, age 1 < 2 years:

[(8.8 mg/d * 212 d) + (100 mg/d * 153 d)]/365 d = 47.0 mgsoil/day

STEP 3: The soil ingestion rates from Step 2 are normalized to the body weight of each age group and weighted for the number of years in that age group (This is important for ages 18<25 and 25<30). This calculation is presented in Table A-3.

TABLE A-3

CALCULATION OF TIME-WEIGHTED AVERAGE DAILY SOIL INGESTION EXPOSURES NORMALIZED TO BODYWEIGHT

AGE	MEDIAN BODY WEIGHT[1]	SOIL INGESTION RATE[2]	WEIGHTING FACTOR[3]	DAILY SOIL INGESTION RATE FOR THE TIME PERIOD[4]
years	kg	mg soil/day	years	(mg * yrs)/(kg * d)
< 1	8.5	0	1	0
1 < 2	10.5	47.0	1	4.5
2 < 3	12.6	54.5	1	4.3
3 < 4	14.6	58.1	1	4
4 < 5	16.4	58.5	1	3.6
5 < 6	18.8	60.1	1	3.2
6 < 7	21.0	21.0	1	1
7 < 8	23.5	21.0	1	0.89
8 < 9	27.3	21.0	1	0.77
9 < 10	29.6	21.0	1	0.71
10 < 11	34.3	21.0	1	0.61
11 < 12	40.0	21.0	1	0.53
12 < 13	45.2	21.0	1	0.46
13 < 14	48.6	21.0	1	0.43
14 < 15	52.8	21.0	1	0.40
15 < 16	53.9	21.0	1	0.39
16 < 17	55.3	21.0	1	0.38
17 < 18	58.3	21.0	1	0.36
18 < 25	57.1	21.0	7	2.6
25 < 30	59.9	21.0	5	3.5

1 - 50th percentile body weights taken from U.S. EPA, 1989b, pp. 5-43 & 5-45.
2 - Soil Ingestion Rate calculated in Table A-2.
3 - Weighting Factor is equal to the number of years represented by each age group.
4 - The Soil Ingestion Rate Normalized to Body Weight for the specified time period.
Example Calculation, age 1 < 2:
[(47.0 mg soil/d) * 1 yr]/10.5 kg = 4.5 (mg * yr)/(kg *d)

STEP 4: Finally, these age-specific values are combined to yield the time-weighted, normalized values used to calculate the risk-based concentration for Category S-1 soil. These values are developed in Table A-4, and the results summarized in Table 5-1.

TABLE A-4

CALCULATION OF THE NORMALIZED DAILY SOIL INTAKE RATES USED FOR S-1 STANDARD SETTING

NONCANCER EFFECTS

AGE years	DAILY SOIL INGESTION RATE FOR THE TIME PERIOD (mg * yrs)/(kg * d)
1 < 2	4.5
2 < 3	4.3
3 < 4	4
4 < 5	3.6
5 < 6	3.2
6 < 7	1
7 < 8	0.89
# Years = 7	SUM: 21.5

Normalized Average Daily Soil Intake Rate:

21.5/7 = 3.1 mg soil/(kg*day)

CARCINOGENIC EFFECTS

AGE years	DAILY SOIL INGESTION RATE FOR THE TIME PERIOD (mg * yrs)/(kg * d)
< 1	0
1 < 2	4.5
2 < 3	4.3
3 < 4	4
4 < 5	3.6
5 < 6	3.2
6 < 7	1
7 < 8	0.89
8 < 9	0.77
9 < 10	0.71
10 < 11	0.61
11 < 12	0.53
12 < 13	0.46
13 < 14	0.43
14 < 15	0.40
15 < 16	0.39
16 < 17	0.38
17 < 18	0.36
18 < 25	2.6
25 < 30	1.8
Exposure Period = 30 yr	SUM: 31

AVERAGING PERIOD
75 Years

Normalized Lifetime Average Daily Soil Intake Rate:

31/75 = 0.41 mg soil/(kg * day)

For the non-cancer risk-based concentration, the averaging period is equal to the exposure period. For cancer risk, the averaging period is a lifetime (75 years), independent of the length of the exposure period (MA DEQE, 1989a).

2. DERMAL CONTACT RATES

This section describes the development of the rates of contact between the soil and the receptor's skin. Absorption through the skin is potentially an important route of exposure which depends, in part, on the exposed skin surface area. Since surface area varies by age, the soil/dermal contact rate would be expected to vary by age as well. The values are age-specific and are normalized to body weight. The exposure model used to quantify the dermal contact exposure pathway assumes that some contact will occur in the home during winter months, but that the majority of the exposure will be received from indoor and outdoor exposures during the warmer time of the year. As a result of the detailed analysis, each age group experiences a slightly different exposure, and the calculated annual average daily contact rates range between approximately 10 to 1200 mg of soil per day. The step-wise process followed in the calculation of the exposure rates is summarized below and detailed in Tables A-5 through A-9.

STEP 1: For exposures which occur indoors, the amount of soil which comes into contact with the receptor's skin is calculated in Table A-5. This contact rate is for those days when exposure is thought to occur. The indoor exposure is quantified for ages 0 - 6. During the colder months only the hands are assumed to be regularly exposed to household dust, and infants are assumed not to be exposed. During the warmer months children are assumed to have a greater surface area exposed. The amount of soil in contact with the skin is dependent upon the surface area of the exposed body parts, the adherence of the dust to the skin, and the fraction of the household dust derived from soil sources.

TABLE A-5

INDOORS ONLY - DERMAL CONTACT

OCTOBER - APRIL

AGE years	Exposed Body Parts and % of Total Body Surface Area[1]	Total Body Surface Area[2] cm^2	Adherence Factor[3] mg/cm^2	Fraction of Dust Derived From Soil[4]	Soil In Contact With Skin On Days Exposed INDOORS ONLY[5] mg soil/day
< 1	none, -	4450[6]	0.056	0.8	-
1 < 2	hands, 5.68%	5130[6]	0.056	0.8	13.1
2 < 3	hands, 5.3%	5790	0.056	0.8	13.7
3 < 4	hands, 6.1%	6490	0.056	0.8	17.7
4 < 5	hands, 5.7%	7060	0.056	0.8	18.0
5 < 6	hands, 5.7%	7790	0.056	0.8	19.9
> 6	none, -	-	0.056	0.8	-

MAY - SEPTEMBER

AGE years	Exposed Body Parts and % of Total Body Surface Area	Total Body Surface Area[2] cm^2	Adherence Factor[3] mg/cm^2	Fraction of Dust Derived From Soil[4]	Soil In Contact With Skin On Days Exposed INDOORS ONLY[5] mg soil/day
< 1	Hands, Arms, Legs, Feet, 46%	4450	0.056	0.8	91.7
1 < 2	Hands, Arms, Legs, Feet, 48%	5130	0.056	0.8	110.3
2 < 3	Hands, Arms, Legs, Feet, 47%	5790	0.056	0.8	121.9
3 < 4	Hands, Arms, Legs, Feet, 54%	6490	0.056	0.8	157.0
4 < 5	Hands, Arms, Legs, Feet, 55%	7060	0.056	0.8	174.0
5 < 6	Hands, Arms, Legs, Feet, 52%[7]	7790	0.056	0.8	181.5
> 6	none, -	-	0.056	0.8	-

1 - Percentage of total body surface area by body part taken from U.S. EPA, 1989b, (mean values, p.4-12).
2 - 50^{th} Percentile values for Total Body Surface Areas taken from U.S. EPA, 1989b (p. 4-31), except as noted below (6).
3 - Hawley, 1985
4 - Hawley, 1985
5 - The soil in contact with the skin (on days exposed) during this time period for the age group specified. Example calculation, age <1: **0.46 * 4450 * 0.056 * 0.8 = 91.7 mg soil**
6 - The total body surface area for ages <1 and 1<2 have been estimated using the equation $SA = K*BW^{2/3}$ (U.S. EPA, 1989b, p. 4-20), where SA = Surface Area, K is a constant (estimated from data available for ages 2<3) and BW is the receptor's body weight (Table 8-8).
7 - Data are unavailable for this age group. The Percentage of total body surface area used here is assumed to be equal to that for the 6 > 7 year old.

STEP 2: For the days when the receptor is exposed both indoors and outdoors, the amount soil in contact is calculated in Table A-6. This contact rate is for those days when exposure is thought to occur. Exposure to adults is quantified here as it is assumed that all ages have the opportunity for contact with the soil through play or gardening.

TABLE A-6

INDOORS & OUTDOORS - DERMAL CONTACT

MAY - SEPTEMBER

AGE years	Exposed Body Parts and % of Total Body Surface Area[1]	Total Body Surface Area[2] cm^2	Adherence Factor[3] mg/cm^2	Fraction Adhered Material Derived from Soil[4]	Soil In Contact With Skin On Days Exposed Both Indoors & Outdoors[5] mg soil/day
< 1	none, -	4450[6]	0.51	0.8	0
1 < 2	Hands, Arms, Legs, Feet, 48%	5130[6]	0.51	0.8	1005
2 < 3	Hands, Arms, Legs, Feet, 47%	5790	0.51	0.8	1110
3 < 4	Hands, Arms, Legs, Feet, 54%	6490	0.51	0.8	1430
4 < 5	Hands, Arms, Legs, Feet, 55%	7060	0.51	0.8	1584
5 < 6	Hands, Arms, Legs, Feet, 52%[7]	7790	0.51	0.8	1653
6 < 7	Hands, Arms, Legs, Feet, 52%	8430	0.51	0.8	1789
7 < 8	Hands, Arms, Legs, Feet, 54%[7]	9170	0.51	0.8	2020
8 < 9	Hands, Arms, Legs, Feet, 54%[7]	10000	0.51	0.8	2203
9 < 10	Hands, Arms, Legs, Feet, 54%	10600	0.51	0.8	2335
10 < 11	Hands, Arms, Legs, Feet, 57%[7]	11700	0.51	0.8	2721
11 < 12	Hands, Arms, Legs, Feet, 57%[7]	13000	0.51	0.8	3023
12 < 13	Hands, Arms, Legs, Feet, 57%	14000	0.51	0.8	3256
13 < 14	Hands, Arms, Legs, Feet, 57%	14800	0.51	0.8	3442
14 < 15	Hands, Arms, Legs, Feet, 59%[7]	15500	0.51	0.8	3731
15 < 16	Hands, Arms, Legs, Feet, 59%[7]	15700	0.51	0.8	3779
16 < 17	Hands, Arms, Legs, Feet, 59%	16000	0.51	0.8	3852
17 < 18	Hands, Arms, Legs, Feet, 61%	16300	0.51	0.8	4057
18 < 30	Hands, Forearms, Lower legs, Feet, 30%	16900	0.51	0.8	2069

1 - Mean values for Percentage of total body surface area by body part taken from U.S. EPA, 1989b (pp. 4-11 & 4-12), except as noted below (7).
2 - 50^{th} Percentile Total Body Surface Areas taken from U.S. EPA, 1989b (pp. 4-29 & 4-31), except as noted below (6).
3 - Hawley, 1985
4 - Hawley, 1985
5 - The soil in contact with the skin (on days exposed) during this time period for the age group specified. Example calculation, age 1 < 2: **0.48 * 5130 * 0.51 * 0.8 = 1005 mg soil/day**
6 - The total body surface area for ages <1 and 1<2 have been estimated using the equation $SA = K*BW^{2/3}$ (U.S. EPA, 1989b, p. 4-20), where SA = Surface Area, K is a constant (estimated from data available for ages 2<3) and BW is the receptor's body weight (Table A-7).
7 - Data are unavailable for this age group. The Percentage of total body surface area used here is taken from the next oldest age group for which data is available (i.e., the % for the 6<7 yr old is used for the 5<6 age group).

STEP 3: The indoor and outdoor soil contact rates (the results of Tables A-5 and A-6, respectively) are then combined with exposure frequency assumptions to yield an average daily soil contact rate for the year. These rates are presented in Table A-7, and range between 10 to 1200 mg soil per day, depending upon the age of the receptor.

TABLE A-7

CALCULATION OF AGE-SPECIFIC SOIL DERMAL CONTACT RATES

	SOIL DERMAL CONTACT RATES ** On days exposed **			FREQUENCY OF EXPOSURE			ANNUAL AVERAGE 365 d
AGE	Indoor Only Oct -> April[1]	Indoor Only May -> Sept.[2]	Indoor & Outdoor May -> Sept.[3]	Indoor Only Oct -> April[4] of 212 days	Indoor Only May -> Sept.[5] of 153 days	Indoor & Outdoor May -> Sept.[6] of 153 days	DAILY SOIL DERMAL CONTACT RATE[7]
years	mg soil/d	mg soil/d	mg soil/d	days	days	days	mg soil/d
< 1	0	91.7	0	0	44	0	11.1
1 < 2	13.1	110.3	1005	212	44	109	321
2 < 3	13.7	121.9	1110	212	44	109	354
3 < 4	17.7	157.0	1430	212	44	109	456
4 < 5	18.0	174.0	1584	212	44	109	504
5 < 6	19.9	181.5	1653	212	44	109	527
6 < 7	0	0	1789	0	0	109	534
7 < 8	0	0	2020	0	0	109	603
8 < 9	0	0	2203	0	0	109	658
9 < 10	0	0	2335	0	0	109	697
10 < 11	0	0	2721	0	0	109	813
11 < 12	0	0	3023	0	0	109	903
12 < 13	0	0	3256	0	0	109	972
13 < 14	0	0	3442	0	0	109	1028
14 < 15	0	0	3731	0	0	109	1114
15 < 16	0	0	3779	0	0	109	1129
16 < 17	0	0	3852	0	0	109	1150
17 < 18	0	0	4057	0	0	109	1212
18 < 30	0	0	2069	0	0	109	618

1 - Indoor Only Contact Rates for Oct. through April taken from Table A-5.
2 - Indoor Only Contact Rates for May through Sept. taken from Table A-5.
3 - Contact Rates on days when both indoor and outdoor exposure is thought to occur taken from Table A-6.
4 - 212 days is approximately 7 days/week from October through April.
5 - 44 days is approximately 2 days/week from May through September.
6 - 109 days is approximately 5 days/week from May through September.
7 - The average daily exposure to soil in dermal contact with the skin for this age group, adjusted for the frequency of exposure.
Example calculation, age 2<3 years:

$$((13.7 * 212) + (121.9 * 44) + (1110 * 109))/365 = 354 \text{ mg soil/day}$$

STEP 4: The annual average contact rates derived in Table A-7 are then normalized to the body weight of each age group and weighted by the number of years in that age group. This calculation is presented in Table A-8.

TABLE A-8

CALCULATION OF TIME-WEIGHTED AVERAGE DAILY SOIL DERMAL CONTACT EXPOSURES NORMALIZED TO BODYWEIGHT

AGE	MEDIAN BODY WEIGHT[1]	SOIL DERMAL CONTACT RATE[2]	WEIGHTING FACTOR[3]	DAILY SOIL DERMAL CONTACT RATE FOR THE TIME PERIOD[4]
years	kilograms	mg soil/day	years	(mg * yrs)/(kg * d)
< 1	8.5	11.1	1	1.3
1 < 2	10.5	321	1	30.6
2 < 3	12.6	354	1	28.1
3 < 4	14.6	456	1	31.2
4 < 5	16.4	504	1	30.7
5 < 6	18.8	527	1	28.0
6 < 7	21.0	534	1	25.4
7 < 8	23.5	603	1	25.7
8 < 9	27.3	658	1	24.1
9 < 10	29.6	697	1	23.5
10 < 11	34.3	813	1	23.7
11 < 12	40.0	903	1	22.6
12 < 13	45.2	972	1	21.5
13 < 14	48.6	1028	1	21.2
14 < 15	52.8	1114	1	21.1
15 < 16	53.9	1129	1	20.9
16 < 17	55.3	1150	1	20.8
17 < 18	58.3	1212	1	20.8
18 < 25	57.1	618	7	75.8
25 < 30	59.9	618	5	51.6

1 - 50^{th} percentile body weights taken from U.S. EPA, 1989b, pp. 5-43 & 5-45.
2 - Soil Dermal Contact calculated in Table A-7.
3 - Weighting Factor is equal to the number of years represented by each age group.
4 - The Soil Dermal Contact Rate Normalized to Body Weight for the specified time period. Example Calculation, age 1< 2:

[(321 mg soil/d) * 1 yr]/10.5 kg = 30.6 (mg * yr)/(kg * d)

STEP 5: Finally, these age-specific values are combined to yield the time-weighted, normalized exposure rates used to calculate the risk-based concentrations. These values are developed in Table A-9 and the results summarized in Table 5-1.

TABLE A-9

CALCULATION OF THE NORMALIZED DAILY SOIL DERMAL CONTACT RATES USED FOR S - 1 STANDARD SETTING

NONCANCER RISK		CANCER RISK	
AGE	DAILY SOIL DERMAL CONTACT RATE FOR THE TIME PERIOD	AGE	DAILY SOIL DERMAL CONTACT RATE FOR THE TIME PERIOD
years	(mg * yrs)/(kg * d)	years	(mg * yrs)/(kg * d)
1 < 2	30.6	< 1	1.3
2 < 3	28.1	1 < 2	30.6
3 < 4	31.2	2 < 3	28.1
4 < 5	30.7	3 < 4	31.2
5 < 6	28.0	4 < 5	30.7
6 < 7	25.4	5 < 6	28.0
7 < 8	25.7	6 < 7	25.4
	--------	7 < 8	25.7
# Years = 7	SUM: 199.7	8 < 9	24.1
		9 < 10	23.5
		10 < 11	23.7
		11 < 12	22.6
		12 < 13	21.5
		13 < 14	21.2
		14 < 15	21.1
		15 < 16	20.9
		16 < 17	20.8
		17 < 18	20.8
		18 < 25	75.8
		25 < 30	51.6

		Exposure Period = 30 yr	SUM: 548.6
		AVERAGING PERIOD 75 Years	
Normalized Average Daily Soil Dermal Contact Rate:		**Normalized Lifetime Average Daily Soil Dermal Contact Rate:**	
199.7/7 = 28.5 mg soil/(kg*day)		**548.6/75 = 7.3 mg soil/(kg * day)**	

For the evaluation of non-cancer risk-base concentrations, the averaging period is equal to the exposure period. For cancer risk-based concentrations, the averaging period is a lifetime (75 years), independent of the length of the exposure period (MA DEQE, 1989a).

APPENDIX B

DERIVATION OF SOIL S-2

NORMALIZED AVERAGE DAILY SOIL INGESTION RATE
(NADSIR)

NORMALIZED AVERAGE DAILY SOIL/SKIN CONTACT RATE
(NADSCR)

NORMALIZED <u>LIFETIME</u> AVERAGE DAILY SOIL INGESTION RATE
(NLADSIR)

NORMALIZED <u>LIFETIME</u> AVERAGE DAILY SOIL/SKIN CONTACT RATE
(NLADSCR)

APPENDIX B

DERIVATION OF SOIL S-2 EXPOSURE RATES

1. SOIL INGESTION RATES:

This section describes the development of the soil ingestion rates used to calculate the S-2 soil standards. These values are age specific and normalized to body weight. The step-wise process followed in the calculation of the exposure rates is summarized below.

STEP 1: An annual average daily soil intake was developed for each age group, as shown in Table B-1. This value is weighted to reflect the relative time spent outdoors where greater exposure to soil would be expected. The resulting soil ingestion rates are then used in Step 2.

TABLE B-1

SOIL S-2
CALCULATION OF AGE-SPECIFIC SOIL INGESTION RATES

	RATE OF EXPOSURE	FREQUENCY OF EXPOSURE		ANNUAL AVERAGE 365 days
AGE	Outdoor Exposure Rate[1]	Winter[2] Nov. -> March of 151 days	Outdoors[3] April -> Oct. of 214 days	DAILY SOIL INGESTION RATE[4]
years	mg soil/d	days	days	mg soil/d
18 < 25	50	0	129	17.7
25 < 35	50	0	129	17.7
35 < 45	50	0	129	17.7

1 - Soil Ingestion Rate on days when outdoor exposures may occur taken from LaGoy (1987)
2 - No outdoor exposure to soil is assumed to occur during this period.
3 - 129 days approximates outdoor exposures 5 days/week, less approximately 24 days when exposure doesn't occur due to weather, vacations, etc...
4 - The average daily soil ingestion rate for this age group, adjusted for the frequency of exposure. Example, age 18 < 25 years:

(50 mg/d * 129 d)/365 days = 17.7 mg soil/day

STEP 2: The soil ingestion rates from Step 1 are normalized to the body weight of each age group and weighted for the number of years in that age group. This calculation is presented in Table B-2.

TABLE B-2

CALCULATION OF TIME-WEIGHTED AVERAGE DAILY SOIL INGESTION EXPOSURES NORMALIZED TO BODYWEIGHT

AGE	MEDIAN BODY WEIGHT[1]	SOIL INGESTION RATE[2]	WEIGHTING FACTOR[3]	DAILY SOIL INGESTION RATE FOR THE TIME PERIOD[4]
years	kilograms	mg soil/day	years	(mg * yrs)/(kg * d)
18 < 25	57.1	17.7	7	2.17
25 < 35	59.9	17.7	10	2.95
35 < 45	62.4	17.7	10	2.84

1 - 50^{th} percentile body weights taken from U.S. EPA, 1989b, pp. 5-43 & 5-45.
2 - Soil Ingestion Rate calculated in Table B-1.
3 - Weighting Factor is equal to the number of years represented by each age group.
4 - The Soil Ingestion Rate Normalized to Body Weight for the specified time period. Example Calculation, age 18 < 25:

[(17.7 mg soil/d) * 7 yr]/57.1 kg = 2.17 (mg * yr)/(kg * d)

STEP 3: Finally, these age-specific values are combined to yield the time-weighted, normalized values used to calculate the risk-based concentration for Category S-2 soil. These values are developed in Table B-3, and the results summarized in Table 5-3.

TABLE B-3

CALCULATION OF THE NORMALIZED DAILY SOIL INTAKE RATES USED TO CALCULATE S-2 SOIL STANDARDS

NONCANCER EFFECTS		CARCINOGENIC EFFECTS	
AGE years	DAILY SOIL INGESTION RATE FOR THE TIME PERIOD (mg * yrs)/(kg * d)	AGE years	DAILY SOIL INGESTION RATE FOR THE TIME PERIOD (mg * yrs)/(kg * d)
18 < 25	2.17	18 < 25	2.17
25 < 35	2.95	25 < 35	2.95
35 < 45	2.84	35 < 45	2.84
# Years = 27	SUM: 7.96	Exposure Period = 27 yr	SUM: 7.96
Normalized Average Daily Soil Intake Rate: **7.96/27 = 0.29 mg soil/(kg*day)**		AVERAGING PERIOD 75 Years	
For the calculation of non-cancer risk-based concentrations, the averaging period is equal to the exposure period. For cancer risk-based concentrations, the averaging period is a lifetime (75 years), independent of the length of the exposure period (MA DEQE, 1989a).		**Normalized Lifetime Average Daily Soil Intake Rate:** **7.96/75 = 0.11 mg soil/(kg * day)**	

2. DERMAL CONTACT RATES

This section will describe the development of the rates of contact between the soil and the receptor's skin. Absorption through the skin is potentially an important route of exposure which depends, in part, on the exposed skin surface area. Since surface area varies by age, the soil/dermal contact rate would be expected to vary by age as well. The values are age-specific and are normalized to body weight. As a result of the detailed analysis, each age group experiences a slightly different exposure. The step-wise process followed in the calculation of the exposure rates is summarized below and detailed in Tables B-4 through B-7.

STEP 1: For outdoor exposures, the amount of soil which comes into contact with the receptor's skin is calculated in Table B-4. This contact rate is for those days when exposure is thought to occur. The amount of soil in contact with the skin is dependent upon the surface area of the exposed body parts and the adherence of the soil to the skin.

TABLE B-4

OUTDOORS - DERMAL CONTACT

APRIL - OCTOBER

AGE years	Exposed Body Parts and % of Total Body Surface Area[1]	Total Body Surface Area[2] cm^2	Adherence Factor[3] mg/cm^2	Soil In Contact With Skin On Days Exposed Outdoors[4] mg soil/day
18 < 25	Hands, Forearms, Lower legs, Feet, 30%	16900	0.51	2586
25 < 35	Hands, Forearms, Lower legs, Feet, 30%	16900	0.51	2586
35 < 45	Hands, Forearms, Lower legs, Feet, 30%	16900	0.51	2586

1 - Mean values for Percentage of total body surface area by body part taken from U.S. EPA, 1989b (pp. 4-11).
2 - 50th Percentile Total Body Surface Areas taken from U.S. EPA, 1989b (pp. 4-29).
3 - Hawley, 1985
4 - The soil in contact with the skin (on days exposed) during this time period for the age group specified. Example calculation,
age 25 < 35:

0.30 * 16900 * 0.51 = 2586 mg soil/day

STEP 2: The outdoor soil contact rates (Table B-4) are then combined with exposure frequency assumptions to yield an average daily soil contact rate for the year. These rates are presented in Table B-5.

TABLE B-5

CALCULATION OF AGE-SPECIFIC SOIL DERMAL CONTACT RATES

	SOIL DERMAL CONTACT RATES ** On days exposed **		FREQUENCY OF EXPOSURE		ANNUAL AVERAGE 365 days
AGE	Winter Nov -> March[1]	Outdoor April -> Oct.[3]	Winter Nov -> March[4] of 151 days	Outdoor April -> Oct.[6] of 214 days	DAILY SOIL DERMAL CONTACT RATE[7]
years	mg soil/day	mg soil/day	days	days	mg soil/d
18 < 25	0	2586	0	129	914
25 < 35	0	2586	0	129	914
35 < 45	0	2586	0	129	914

1 - No exposure to soil is thought to occur during this time.
2 - Contact Rates on days when outdoor exposure is thought to occur taken from Table B-4.
3 - 129 days approximates outdoor exposures 5 days/week, less approximately 24 days when exposure doesn't occur due to weather, vacations, etc...
4 - The average daily exposure to soil in dermal contact with the skin for this age group, adjusted for the frequency of exposure. Example calculation, age 25 < 35 years:

(2586 * 129)/365 = 914 mg soil/day

STEP 3: The annual average contact rates derived in Table B-5 are then normalized to the body weight of each age group and weighted by the number of years in that age group. This calculation is presented in Table B-6.

TABLE B-6

CALCULATION OF TIME-WEIGHTED AVERAGE DAILY SOIL DERMAL CONTACT EXPOSURES NORMALIZED TO BODYWEIGHT

AGE	MEDIAN BODY WEIGHT[1]	SOIL DERMAL CONTACT RATE[2]	WEIGHTING FACTOR[3]	DAILY SOIL DERMAL CONTACT RATE FOR THE TIME PERIOD[4]
years	kilograms	mg soil/day	years	(mg * yrs)/(kg * d)
18 < 25	57.1	914	7	112.0
25 < 35	59.9	914	10	152.6
35 < 45	62.4	914	10	146.5

1 - 50^{th} percentile body weights taken from U.S. EPA, 1989b, pp. 5-43.
2 - Soil Dermal Contact calculated in Table B-5.
3 - Weighting Factor is equal to the number of years represented by each age group.
4 - The Soil Dermal Contact Rate Normalized to Body Weight for the specified time period. Example Calculation, age 35 < 45:

[(914 mg soil/d) * 10 yr]/62.4 kg = 146.5 (mg * yr)/(kg * d)

STEP 4: Finally, these age-specific values are combined to yield the time-weighted, normalized exposure rates used to calculate the risk-based concentrations. These values are developed in Table B-7 and the results summarized in Table 5-1.

TABLE B-7

CALCULATION OF THE NORMALIZED DAILY SOIL DERMAL CONTACT RATES USED TO CALCULATE S-2 STANDARDS

NONCANCER EFFECTS		CARCINOGENIC EFFECTS	
AGE years	DAILY SOIL DERMAL CONTACT RATE FOR THE TIME PERIOD (mg * yrs)/(kg * d)	AGE years	DAILY SOIL DERMAL CONTACT RATE FOR THE TIME PERIOD (mg * yrs)/(kg * d)
18 < 25	112.0	18 < 25	112.0
25 < 35	152.6	25 < 35	152.6
35 < 45	146.5	35 < 45	146.5
	--------		--------
# Years = 27	SUM: 411.1	Exposure Period = 27 yr	SUM: 411.1
		AVERAGING PERIOD 75 Years	
Normalized Average Daily Soil Dermal Contact Rate: **411.1/27 = 15.2 mg soil/(kg*day)**		**Normalized Lifetime Average Daily Soil Dermal Contact Rate:** **411.1/75 = 5.48 mg soil/(kg * day)**	
For the non-cancer risk concentration, the averaging period is equal to the exposure period. For cancer risk, the averaging period is a lifetime (75 years), independent of the length of the exposure period (MA DEQE, 1989a).			

APPENDIX C

DERIVATION OF SOIL S-3

NORMALIZED AVERAGE DAILY SOIL INGESTION RATE (NADSIR)

NORMALIZED AVERAGE DAILY SOIL/SKIN CONTACT RATE (NADSCR)

NORMALIZED <u>LIFETIME</u> AVERAGE DAILY SOIL INGESTION RATE (NLADSIR)

NORMALIZED <u>LIFETIME</u> AVERAGE DAILY SOIL/SKIN CONTACT RATE (NLADSCR)

APPENDIX C

DERIVATION OF SOIL S-3 EXPOSURE RATES

1. SOIL INGESTION RATES:

This section describes the development of the soil ingestion rates used to calculate the S-3 soil standards. These values are age specific and normalized to body weight. The step-wise process followed in the calculation of the exposure rates is summarized below.

STEP 1: An annual average daily soil intake was developed for each age group, as shown in Table C-1. This value is weighted to reflect the relative time spent outdoors where greater exposure to soil would be expected. The resulting soil ingestion rates are then used in Step 2.

TABLE C-1

SOIL S-3
CALCULATION OF AGE-SPECIFIC SOIL INGESTION RATES

	RATE OF EXPOSURE	FREQUENCY OF EXPOSURE			
AGE	Outdoor Exposure Rate[1]	June, July, August[2] of 92 days	April, May, Sept, Oct.[3] of 122 days	Averaging Period[4]	DAILY SOIL INGESTION RATE[5]
years	mg soil/d	days	days	days	mg soil/d
18 < 25	50	56	73	365	17.7
22	50	66	0	92	35.9

1 - Soil Ingestion Rate on days when outdoor exposures may occur taken from LaGoy (1987)
2 - 56 days approximates 5 days/week less 10 days when exposure doesn't occur due to weather, vacations, etc... 66 days assumes 5 days/week.
3 - 73 days approximates outdoor exposures 5 days/week, less approximately 15 days when exposure doesn't occur due to weather, vacations, etc...
4 - The seven year exposure is expressed as an annual (365 day) average, but the 3 month exposure is averaged over the exposure period.
5 - The average daily soil ingestion rate for this age group, adjusted for the frequency of exposure. Example, age 18 < 25 years:

$$((50 \text{ mg/d} * 56 \text{ d}) + (50 \text{ mg/d} * 73 \text{ d}))/365 \text{ days} = 17.7 \text{ mg soil/day}$$

STEP 2: The soil ingestion rates from Step 1 are normalized to the body weight of each age group and weighted for the number of years in that age group. This calculation is presented in Table C-2.

TABLE C-2

CALCULATION OF TIME-WEIGHTED AVERAGE DAILY SOIL INGESTION EXPOSURES NORMALIZED TO BODYWEIGHT

AGE years	MEDIAN BODY WEIGHT[1] kilograms	SOIL INGESTION RATE[2] mg soil/day	WEIGHTING FACTOR[3]	DAILY SOIL INGESTION RATE FOR THE TIME PERIOD[4]
18 < 25	57.1	17.7	7	2.17 (mg*yrs)/(kg*d)
22	57.1	35.9	92	57.8 (mg*d)/(kg*d)

1 - 50th percentile body weights taken from U.S. EPA, 1989b, pp. 5-43.
2 - Soil Ingestion Rate calculated in Table C-1.
3 - Weighting Factor is equal to the number of years or days represented by each age group.
4 - The Soil Ingestion Rate Normalized to Body Weight for the specified time period. Example Calculation, age 18 < 25:

[(17.7 mg soil/d) * 7 yr]/57.1 kg = 2.17 (mg * yr)/(kg * d)

STEP 3: Finally, these age-specific values are combined to yield the time-weighted, normalized values used to calculate the risk-based concentration for Category S-3 soil. These values are developed in Table C-3, and the results summarized in Table 5-1.

TABLE C-3

CALCULATION OF THE NORMALIZED DAILY SOIL INTAKE RATES USED TO CALCULATE S-3 SOIL STANDARDS

NONCANCER EFFECTS		CARCINOGENIC EFFECTS	
AGE	DAILY SOIL INGESTION RATE FOR THE TIME PERIOD	AGE	DAILY SOIL INGESTION RATE FOR THE TIME PERIOD
years	(mg * yrs)/(kg * d)	years	(mg * yrs)/(kg * d)
22	57.8	18 < 25	2.17
# days = 92	--------		--------
	SUM: 57.8	Exposure Period = 7 yr	SUM: 2.17
Normalized Average Daily Soil Intake Rate:		AVERAGING PERIOD 75 Years	
57.8/92 = 0.63 mg soil/(kg*day)		**Normalized Lifetime Average Daily Soil Intake Rate:**	
For the calculation of non-cancer risk-based concentrations, the averaging period is equal to the exposure period. For cancer risk-based concentrations, the averaging period is a lifetime (75 years), independent of the length of the exposure period (MA DEQE, 1989a).		**2.17/75 = 0.029 mg soil/(kg * day)**	

2. DERMAL CONTACT RATES

This section describes the development of the rates of contact between the soil and the receptor's skin. Absorption through the skin is potentially an important route of exposure which depends, in part, on the exposed skin surface area. Since surface area varies by age, the soil/dermal contact rate would be expected to vary by age as well. The values are age-specific and normalized to body weight. As a result of the detailed analysis, each age group experiences a slightly different exposure. The step-wise process followed in the calculation of the exposure rates is summarized below and detailed in Tables C-4 through C-7.

STEP 1: For outdoor exposures, the amount of soil which comes into contact with the receptor's skin is calculated in Table C-4. This contact rate is for those days when exposure is thought to occur. The amount of soil in contact with the skin is dependent upon the surface area of the exposed body parts and the adherence of the soil to the skin.

TABLE C-4

OUTDOORS - DERMAL CONTACT

APRIL - OCTOBER

AGE years	Exposed Body Parts and % of Total Body Surface Area[1]	Total Body Surface Area[2] cm^2	Adherence Factor[3] mg/cm^2	Soil In Contact With Skin On Days Exposed Outdoors[5] mg soil/day
18 < 25	Hands, Forearms, Lower legs, Feet, 30%	16900	0.51	2586
22	Hands, Forearms, Lower legs, Feet, 30%	16900	0.51	2586

1 - Mean values for Percentage of total body surface area by body part taken from U.S. EPA, 1989b (pp. 4-11).
2 - 50th Percentile Total Body Surface Areas taken from U.S. EPA, 1989b (pp. 4-29).
3 - Hawley, 1985
4 - The soil in contact with the skin (on days exposed) during this time period for the age group specified. Example calculation, age 18 < 25:

0.30 * 16900 * 0.51 = 2586 mg soil/day

STEP 2: The outdoor soil contact rates (Table C-4) are then combined with exposure frequency assumptions to yield an average daily soil contact rate for the year. These rates are presented in Table C-5.

TABLE C-5

CALCULATION OF AGE-SPECIFIC SOIL DERMAL CONTACT RATES						
	SOIL DERMAL CONTACT RATES ** On days exposed **		FREQUENCY OF EXPOSURE			
AGE	June, July, August[1]	April, May, Sept, Oct.[1]	June, July August[2] of 92 days	April, May, Sept, Oct.[3] of 122 days	Averaging Period[4]	DAILY SOIL DERMAL CONTACT RATE[5]
years	mg soil/day	mg soil/day	days	days		mg soil/d
18 < 25	2586	2586	56	73	365 days	914
22	2586	2586	66	0	92 days	1855

1 - Contact Rates on days when outdoor exposure is thought to occur taken from Table C-4.
2 - 56 days approximates 5 days/week less 10 days when exposure doesn't occur due to weather, vacations, etc... 66 days assumes 5 days/week.
3 - 73 days approximates outdoor exposures 5 days/week, less approximately 15 days when exposure doesn't occur due to weather, vacations, etc...
4 - The seven year exposure is expressed as an annual (365 day) average, but the 3 month exposure is averaged over the exposure period.
5 - The average daily exposure to soil in dermal contact with the skin for this age group, adjusted for the frequency of exposure. Example calculation, age 18 < 25 years:

((2586 * 56) + (2586 * 73))/365 = 914 mg soil/day

STEP 3: The annual average contact rates derived in Table C-5 are then normalized to the body weight of each age group and weighted by the number of years in that age group. This calculation is presented in Table C-6.

TABLE C-6

CALCULATION OF TIME-WEIGHTED AVERAGE DAILY SOIL DERMAL CONTACT EXPOSURES NORMALIZED TO BODYWEIGHT				
AGE	MEDIAN BODY WEIGHT[1]	SOIL DERMAL CONTACT RATE[2]	WEIGHTING FACTOR[3]	DAILY SOIL DERMAL CONTACT RATE FOR THE TIME PERIOD[4]
years	kilograms	mg soil/day	years	
18 < 25	57.1	914	7	112.0 (mg * yrs)/(kg * d)
22	57.1	1855	92	2988.8 (mg * d)/(kg * d)

1 - 50th percentile body weights taken from U.S. EPA, 1989b, pp. 5-43.
2 - Soil Dermal Contact calculated in Table C-5.
3 - Weighting Factor is equal to the time (years & days, respectively) represented by each age group.
4 - The Soil Dermal Contact Rate Normalized to Body Weight for the specified time period. Example Calculation, age 18 < 25: **[(914 mg soil/d) * 7 yr]/57.1 kg = 112.0 (mg * yr)/(kg * d)**

STEP 4: Finally, these age-specific values are combined to yield the time-weighted, normalized exposure rates used to calculate the risk-based concentrations. These values are developed in Table C-7 and the results summarized in Table 5-1.

TABLE C-7

CALCULATION OF THE NORMALIZED DAILY SOIL DERMAL CONTACT RATES USED TO CALCULATE S-3 STANDARDS

NONCANCER EFFECTS		CARCINOGENIC EFFECTS	
AGE years	DAILY SOIL DERMAL CONTACT RATE FOR THE TIME PERIOD (mg * yrs)/(kg * d)	AGE years	DAILY SOIL DERMAL CONTACT RATE FOR THE TIME PERIOD (mg * yrs)/(kg * d)
22	2988.8	18 < 25	112.0
	--------	Exposure Period = 7 yr	SUM: 112.0
# days = 92	SUM: 2988.8	AVERAGING PERIOD 75 Years	
Normalized Average Daily Soil Dermal Contact Rate: **2988.8/92 = 32.5 mg soil/(kg*day)**			
For the evaluation of non-cancer risk, the averaging period is equal to the exposure period. For cancer risk, the averaging period is a lifetime (75 years), independent of the length of the exposure period (MA DEQE, 1989a).		**Normalized Lifetime Average Daily Soil Dermal Contact Rate:** **112.0/75 = 1.5 mg soil/(kg * day)**	

APPENDIX D

SOIL LEVELS WHICH TRIGGER AN IMMINENT HAZARD EVALUATION

SOIL LEVELS WHICH TRIGGER AN IMMINENT HAZARD EVALUATION

NOTE: *These levels are set generically to be protective under most exposure conditions. As such, the concentrations which follow are used to "screen in" conditions which may require further assessment or remedial action in the short-term. These trigger levels cannot be used to definitively "screen out" a disposal site, as it is possible (under more extreme exposure conditions) that concentrations below these levels could pose an imminent hazard. A site-specific assessment may conclude that the conditions at a disposal site pose an Imminent Hazard at concentrations which are higher or lower than those presented in the regulations.*

310 CMR 40.0321(2)(b)

Hazardous Material	CAS Number	Concentration (μg/g dry wt)
Arsenic (total)	7440382	40
Cadmium (total)	7440439	60
Chromium (VI)	18540299	10,000
Cyanide (available)	57125	100
Mercury (total)	7439976	300
Methyl Mercury	22967926	10
PCB (total)	1336363	10

APPLICABILITY:

- Oil and/or hazardous material within a depth of 6 inches below the ground surface, and
- Within 500 feet of a residential dwelling, school, playground or public park, unless human access is controlled or prevented by means of bituminous pavement, concrete, or other physical barrier.

CONSEQUENCE:

- **Report to the Department** as soon as possible but not more than two hours after obtaining knowledge that a release meets these criteria.
- **Immediate Response Action (IRA) is required**. Immediate Response Actions are assessment and/or remedial actions undertaken in an expeditious manner to address sudden releases, Imminent Hazards and other time-critical release or site conditions. IRAs must taken whenever and wherever timely actions are required to assess, eliminate, abate or mitigate adverse or unacceptable release, threat of release and/or site conditions.
- Demonstration may be made to the Department by a preponderance of evidence that the conditions do not pose an Imminent Hazard.

EXPOSURES CONSIDERED

The Imminent Hazard Trigger Levels were identified through the evaluation of both carcinogenic and non-cancer risks: the lower of the two estimated concentrations is chosen to be the Trigger Level in order to be protective of both types of health effect. Due to the markedly different nature of these health effects, the calculations performed to evaluate the risks also differ. The following sections describe first the exposures assumed for the cancer risk calculations and then those assumed to evaluate the risk of non-cancer health impacts.

In general, the evaluation of soil ingestion and dermal contact exposures follows the methodology presented in various sections of this document, the *Summary of Interim Procedures and Assumptions Used in Relating Soil Contaminant Levels and Risk to Human Health* (MA DEP, 1993b), and in Section 8.0 of the *Documentation for the Risk Assessment ShortForm - Residential Scenario* (Policy #WSC/ORS-142-92, MA DEP, 1992). This approach uses age-specific exposure factors (such as body weight and skin surface area) to develop a time-weighted average exposure for each identified receptor.

Exposures Evaluated for the Cancer Risk Evaluation:

By definition, an Imminent Hazard is a hazard which would pose a significant risk if it were present for even a short period of time. The toxicological and risk assessment models used to estimate cancer risk, however, traditionally evaluate long-term exposure to environmental contaminants and are based upon a "*Lifetime Average Daily Dose*" of the substance. While the current state and federal approach to regulating carcinogens assumes that any exposure to a carcinogenic material is associated with some incremental cancer risk, estimating the incremental risk associated with a short exposure is problematic.

It is possible, however, to identify long-term risks which are so great that they indicate a need for remedial action in the short-term. This is the approach for developing the Imminent Hazard Trigger Levels: an excess lifetime cancer risk of one-in-ten-thousand (based on a 30-year exposure) is taken to be indicative of significant *short-term* cancer risk.

The Trigger Levels are applicable in areas where frequent exposure to surficial soil is likely. This exposure scenario is thus analogous to a residential exposure, and the exposure assumptions used in the development of the MCP Method 1 S-1 Soil Standards and the *Risk Assessment ShortForm - Residential Scenario* would be consistent with how the Trigger levels will be applied.

The residential exposure scenario assumes that a person (*receptor*) lives in a dwelling for thirty years. (The US EPA estimates that 95% of the population typically lives in the same location for less than thirty years). As children generally experience the highest exposures due to their play activities and low body weight, this analysis focuses on the ages of 0 to 30 years. Exposure to contaminated soil is assumed to vary by age and time of year. In the winter months (October through April), exposure is limited to soil which is part of household dust. In the warmer months, direct exposure to outdoor soil is also considered.

Equations:

$$[OHM]_{IHTL} = \frac{ELCR * C}{CSF * ((NLADSIR * RAF_3) + (NLADSCR * RAF_4))}$$

Where:

$[OHM]_{IHTL}$	=	The calculated Imminent Hazard Trigger Level concentration in soil, for the oil or hazardous material. In units: mg/kg.
ELCR	=	The target Excess Lifetime Cancer Risk: 1×10^{-4} (dimensionless).
C	=	Units Concersion Factor: 1,000,000 mg/kg.
NLADSIR	=	Time-weighted Normalized Lifetime Average Daily Soil Ingestion Rate (normalized to bodyweight). In units: mg_{soil}/kg/day.
RAF	=	Relative Absorption Factor for soil ingestion or dermal contact for cancer risk calculations (a chemical-, medium-, route- and health-endpoint specific value). Dimensionless.
NLADSCR	=	Time-weighted Normalized Lifetime Average Daily Soil Dermal Contact Rate (normalized to bodyweight). In units: mg_{soil}/kg/day
CSF	=	The oral Carcinogenic Slope Factor for the oil or hazardous material. In units of 1/(mg/kg/day).

and

$$NLADSIR = \frac{\sum_{i=0}^{30\ years} \frac{(I1_i * F1) + (I2_i * (F2 + F3))}{BW_i * 365\ days}}{75\ years}$$

$$NLADSIR = 0.41\ mg_{\underline{soil}}/(kg_{\underline{BW}} * day)$$

and

$$NLADSCR = \frac{\sum_{i=0}^{30\ years} \left(\frac{SA_i * FA * ((\%T1_i * AF1 * F1) + (\%T2_i * AF2 * F2) + (\%T3_i * AF3 * F3))}{BW_i * 365\ days}\right)}{75\ years}$$

$$NLADSCR = 7.3\ mg_{\underline{soil}}/(kg_{\underline{BW}} * day)$$

Exposure Assumptions *(Cancer Risk):*

Receptor:		Resident	Aged 0 to 30 years
Exposure Duration:		30 years	
Frequency of Exposure:	F1:	212 days/year	Ages 1 to 6, indoor only: October -> April
	F2:	44 days/year	Ages 1 to 30, indoor only: May -> September
	F3:	109 days/year	Ages 1 to 30, indoor & outdoor: May -> September
Body Weight:	BW_i:	8.5 - 59.9 kg	Ages 0 to 30, age dependent
Soil Ingestion Rate:	$I1_i$	8-31 mg/day	Ages 1 to 6, indoor only, age dependent
	$I2_i$:	100 mg/day	Ages 1 to 6, indoor & outdoor exposures: May -> September
		50 mg/day	Ages 6 to 30, indoor & outdoor exposures: May -> September
Exposed Surface Area:	SA_i:	4450-16900 cm^2	Ages 0 to 30 years, total body surface area, age dependent
	$\%T1_i$:	5.3 - 5.7%	Ages 1 to 6 years, Percentage of total body surface area comprised by the hands only, indoor exposures: Oct. -> April.
	$\%T2_i$:	46 - 55%	Ages 1 to 6 years, Percentage of total body surface area comprised by the hands, arms, legs and feet, indoor exposures: May -> September.
	$\%T3_i$:	46 - 61%	Ages 1 to 18 years, Percentage of total body surface area comprised by the hands, arms, legs and feet, indoor & outdoor exposures: May -> September.
		30%	Ages 19 to 30 years, Percentage of total body surface area comprised of the hands, forearms, lower legs and feet: indoor & outdoor exposures: May -> September.
Soil Adherence Factor:	AF1:	0.056 mg/cm^2	Adherence of indoor dust to skin
	AF2:	0.51 mg/cm^2	Adherence of soil to skin
Fraction of Adhered Material Derived From Soil:	FA:	80 %	
Averaging Period:	AP:	75 years	A lifetime

Non-cancer Risk Evaluation:

Imminent Hazard Trigger levels also consider the potential for non-cancer health effects (such as central nervous system disorders) following exposure to oil or hazardous material. This evaluation is performed differently from the cancer risk-based calculation.

When evaluating non-cancer risk, the site-related exposure (or *dose*) experienced by the receptor is compared to a dose from the scientific literature at which no adverse health impacts would be expected. If the site-related dose is less than the identified literature value (or *Reference Dose*), then the site conditions do not pose an imminent hazard.

If the site-related dose is greater than the Reference Dose, then adverse health effects cannot be ruled out, ***but the risk assessor cannot immediately conclude that the site conditions pose an imminent hazard***. Due to large variations in the quality of toxicological data available, the US EPA incorporates "*Uncertainty Factors* (UFs)" and "*Modifying Factors* (MFs)" into the Reference Dose to reflect the quality of the data and to insure that the Reference Dose falls below a No Observed Adverse Effects Level in sensitive humans. The less confidence there is in the original data, the larger the UFs and MFs. It is not uncommon that a Reference Dose incorporates combined factors as large as 10,000. On the other hand, the toxicological information available for some chemicals is complete, and the Uncertainty and Modifying Factors used to adjust the Reference Dose are quite small: sometimes less than a factor of ten. Thus the interpretation of a site-related exposure which exceeds a Reference Dose depends in part upon the magnitude of the UFs and MFs incorporated into the Reference Dose.

The ratio of the site-related dose over the Reference Dose is called the **Hazard Index** *(or HI). In consideration of the magnitude of the Uncertainty Factors and Modifying Factors incorporated into the Refernce Dose, the following criteria are used to calculate the Imminent Hazard Trigger Levels:*

- *If the magnitude of the UFs and MFs is* **equal to or less than 10**, *then the trigger levels are set at a Hazard Index = 1.*
- *If the magnitude of the UFs and MFs is* **greater than 10**, *then the trigger levels are set at a Hazard Index = 10.*

The Reference Doses chosen to evaluate the site-realted exposures should reflect the duration of the exposure itself. If the risk assessment looks at chronic exposures, then a chronic Reference Dose should be used. The evaluation of acute or subchronic exposures should employ acute or subchronic Reference Doses when they are available.

Exposures Evaluated for the Non-cancer Risk Evaluation:

The Trigger Levels are applicable in areas where frequent exposure to surficial soil is likely. This exposure scenario is thus analogous to a residential exposure, and the exposure assumptions used in the development of the MCP Method 1 S-1 Soil Standards and the *Risk Assessment ShortForm - Residential Scenario* would be consistent with how the Trigger levels will be applied. In a residential scenario, young children generally experience higher rates of exposure due to the nature of their activities and their low body weights. Thus this evaluation focuses on a child aged 5-6 years old exposed during the summer months (June through August) when frequent contact with soil is likely.

Equations:

$$[OHM]_{IHTL} = \frac{HI * RfD * C}{((ADSIR * RAF_1) + (ADSCR * RAF_2))}$$

Where:

$[OHM]_{IHTL}$	=	The calculated Imminent Hazard Trigger Level concentration in soil, for the oil or hazardous material. In units: mg/kg.
HI	=	The target Hazard Index level: 1 or 10, depending upon the magnitude of the UFs and MFs incorporated into the RfD (dimensionless).
RfD	=	The oral Reference Dose or substitute toxicity value identified for the oil or hazardous material. In units of: mg/kg/day.
C	=	Units Concersion Factor: 1,000,000 mg/kg.
ADSIR	=	Average Daily Soil Ingestion Rate (normalized to bodyweight). In units: mg_{soil}/kg/day.
RAF	=	Relative Absorption Factor for soil ingestion or dermal contact for cancer risk calculations (a chemical-, medium-, route- and health-endpoint specific value). Dimensionless.
ADSCR	=	Average Daily Soil Dermal Contact Rate (normalized to bodyweight). In units: mg_{soil}/kg/day

and

$$ADSIR = \frac{I * F * D}{BW * AP}$$

$$ADSIR = 5.3\ mg_{\underline{soil}}/(kg_{\underline{BW}} * day)$$

and

$$ADSCR = \frac{SA * \%T * AF * FA * F * D}{BW * AP}$$

$$ADSCR = 87.9\ mg_{\underline{soil}}/(kg_{\underline{BW}} * day)$$

***Exposure Assumptions** (Non-Cancer Risk):*

Receptor:		Child Resident	Aged 5 to 6 years
Exposure Duration:	D:	3 months	
Frequency of Exposure:	F:	7 days/week, over 3 summer months:	92 days/3 months
Body Weight:	BW:	18.8 kg	Mean BW for child 5-6 years
Soil Ingestion Rate:	I	100 mg/day	
Exposed Surface Area:	SA:	7790 cm^2	Age 5 to 6 years, total body surface area
	%T:	52%	Age 5 to 6 years, Percentage of total body surface area comprised by the hands, arms, legs and feet.
Soil Adherence Factor:	AF:	0.51 mg/cm^2	Adherence of soil to skin
Fraction of Adhered Material Derived From Soil:	FA:	80 %	
Averaging Period:	AP:	92 days	3 months, summer exposure

Arsenic

BASIS: Lowest Risk-Based Concentration:

Cancer: 30 year residential exposure, ages 0 to 30. Exposure parameters are age-specific and normalized to body weight (see earlier discussion for the calculation of soil exposure rates). Target risk level = one-in-ten thousand (10^{-4}). Carcinogenic Slope Factor = 1.75 per mg/kg/day, from USEPA *Integrated Risk Information System (IRIS)*.

$$[OHM]_{soil} = (ELCR \times C)/(CSF \times ((RAF_{oral} \times NLADSIR) + (RAF_{dermal} \times NLADSCR)))$$

$$[OHM]_{soil} = (10^{-4} \times 10^{6})/(1.75 \times ((1 \times 0.41) + (0.03 \times 7.3)))$$

$$[OHM]_{soil,\ cancer} = 90.8\ mg/kg$$

Noncancer: A 3 month (subchronic) residential exposure for a child age 5 < 6 years. Exposure assumed to occur daily (indoor & outdoor) over that period. Exposure parameters are age-specific (see earlier discussion for the calculation of soil exposure rates). Subchronic Reference Dose = 0.0003 mg/kg/day from USEPA *Health Effects Assessment Summary Tables (HEAST)*. Target Hazard Index value = 1 based upon the magnitude (3) of Uncertainty Factors and Modifying Factors used to derive the Subchronic Reference Dose.

$$[OHM]_{soil} = (HI_{IH} \times RfD_{subchronic} \times C)/((ADSIR \times RAF_{oral}) + (ADSCR \times RAF_{dermal}))$$

$$[OHM]_{soil} = (1 \times 0.0003 \times 10^{6})/((5.3 \times 1) + (87.9 \times 0.03))$$

$$[OHM]_{soil,\ noncancer} = 37.8\ mg/kg$$

The Imminent Hazard Soil Trigger Level for Arsenic is based upon the potential non-cancer risks: 37.8 mg/kg < 90.8 mg/kg. Expressed in one significant figure, 37.8 rounds to 40 mg/kg (ppm).

$$Arsenic_{I.H.\ Trigger,\ Soil} = 40\ mg/kg$$

Cadmium

BASIS: Lowest Risk-Based Concentration:

Cancer: Cadmium is not considered to be carcinogenic for exposures via the oral or dermal routes (USEPA *Integrated Risk Information System*).

Noncancer: A 3 month (subchronic) residential exposure for a child age 5 < 6 years. Exposure assumed to occur daily (indoor & outdoor) over that period. Exposure parameters are age-specific (see earlier discussion for the calculation of soil exposure rates). Subchronic Reference Dose = 0.001 mg/kg/day assumed to be equal to the chronic Reference Dose from USEPA *Integrated Risk Information System (IRIS)*. Target Hazard Index value = 1 based upon the magnitude (10) of Uncertainty Factors and Modifying Factors used to derive the Subchronic Reference Dose.

$$[OHM]_{soil} = (HI_{IH} \times RfD_{subchronic} \times C)/((ADSIR \times RAF_{oral}) + (ADSCR \times RAF_{dermal}))$$

$$[OHM]_{soil} = (1 \times 0.001 \times 10^{6})/((5.3 \times 1) + (87.9 \times 0.14))$$

$$[OHM]_{soil,\ noncancer} = 56.8\ mg/kg$$

The Imminent Hazard Soil Trigger Level for Cadmium is based upon the potential non-cancer risks: 56.8 mg/kg. No cancer risk-based concentration was calculated as cadmium is not considered to be carcinogenic via the oral or dermal routes of exposure. Expressed in one significant figure, 56.8 rounds to 60 mg/kg (ppm).

$$\mathbf{Cadmium_{I.H.\ Trigger,\ Soil} = 60\ mg/kg}$$

Chromium (VI)

BASIS: Lowest Risk-Based Concentration:

Cancer: Chromium (VI) is not considered to be carcinogenic for exposures via the oral or dermal routes (USEPA *Integrated Risk Information System*).

Noncancer: A 5 month (subchronic) residential exposure for a child age 5 < 6 years. Exposure assumed to occur daily (indoor & outdoor) over that period. Exposure parameters are age-specific (see earlier discussion for the calculation of soil exposure rates). Subchronic Reference Dose = 0.02 mg/kg/day assumed to be equal to the chronic Reference Dose from USEPA *Integrated Risk Information System (IRIS)*. Target Hazard Index value = 10 based upon the magnitude (100) of Uncertainty Factors and Modifying Factors used to derive the Subchronic Reference Dose.

$$[OHM]_{soil} = (HI_{IH} \times RfD_{subchronic} \times C)/((ADSIR \times RAF_{oral}) + (ADSCR \times RAF_{dermal}))$$

$$[OHM]_{soil} = (10 \times 0.02 \times 10^6)/((5.3 \times 1) + (87.9 \times 0.1))$$

$$[OHM]_{soil,\ noncancer} = 14194 \text{ mg/kg}$$

The Imminent Hazard Soil Trigger Level for Chromium (VI) is based upon the potential non-cancer risks: 14194 mg/kg. No cancer risk-based concentration was calculated as hexavalent chromium is not considered to be carcinogenic via the oral or dermal routes of exposure. Expressed in one significant figure, 14194 rounds to 10,000 mg/kg (ppm).

$$\textbf{Chromium (VI)}_{I.H.\ Trigger,\ Soil} = \textbf{10,000 mg/kg}$$

Cyanide

BASIS: Lowest Risk-Based Concentration:

Cancer: Cyanide is not considered to be carcinogenic for exposures via the oral or dermal routes (USEPA Integrated Risk Information System).

Noncancer: A one-time (acute) residential exposure for a 2 year old child who weighs 10 kg. The acute exposure scenario assumes that a child may ingest one gram (10^3 mg) of soil as a one-time event, and that 100% of the physiologically available cyanide is absorbed. Dermal exposure was considered to be insignificant relative to the ingestion pathway for this acute exposure. The Allowable One-Time Absorbed Dose (AOTAD) = 0.01 mg/kg, derived from Gettler and Baine (1938), as described in *Background Documentation for the Development of "Available" Cyanide Benchmark Concentrations* (MA DEP, 1991). Target Hazard Index value = 1 based upon the severity of effect (lethality) which is the basis of the allowable dose.

$$[OHM]_{soil} = (HI_{IH} \times AOTAD_{acute} \times BW \times C)/(I_{acute} \times RAF_{oral})$$

$$[OHM]_{soil} = (1 \times 0.01 \text{ mg/kg} \times 10 \text{ kg} \times 10^6 \text{ mg/kg})/(10^3 \text{ mg-soil} \times 1)$$

$$[OHM]_{soil,\ noncancer} = 100 \text{ mg/kg}$$

The Imminent Hazard Soil Trigger Level for Cyanide is based upon the potential non-cancer risks: 100 mg/kg. No cancer risk-based concentration was calculated as cyanide is not considered to be carcinogenic.

$$\textbf{Cyanide}_{I.H.\ Trigger,\ Soil} = \textbf{100 mg/kg}$$

Mercury

BASIS: Lowest Risk-Based Concentration:

Cancer: Mercury is not considered to be carcinogenic (USEPA *Integrated Risk Information System*).

Noncancer: A 5 month (subchronic) residential exposure for a child age 5 < 6 years. Exposure assumed to occur daily (indoor & outdoor) over that period. Exposure parameters are age-specific (see earlier discussion for the calculation of soil exposure rates). Subchronic Reference Dose = 0.0003 mg/kg/day from USEPA *Health Effects Assessment Summary Tables (HEAST)*. Target Hazard Index value = 10 based upon the magnitude (30) of Uncertainty Factors and Modifying Factors used to derive the Subchronic Reference Dose.

$$[OHM]_{soil} = (HI_{IH} \times RfD_{subchronic} \times C)/((ADSIR \times RAF_{oral}) + (ADSCR \times RAF_{dermal}))$$

$$[OHM]_{soil} = (10 \times 0.0003 \times 10^{6})/((5.3 \times 1) + (87.9 \times 0.05))$$

$$[OHM]_{soil,\ noncancer} = 309\ mg/kg$$

The Imminent Hazard Soil Trigger Level for Mercury is based upon the potential non-cancer risks: 309 mg/kg. No cancer risk-based concentration was calculated as mercury is not considered to be carcinogenic. Expressed in one significant figure, 309 rounds to 300 mg/kg (ppm).

$$\mathbf{Mercury_{I.H.\ Trigger,\ Soil} = 300\ mg/kg}$$

Methyl Mercury

BASIS: Lowest Risk-Based Concentration:

Cancer: Methyl Mercury is not considered to be carcinogenic (USEPA *Integrated Risk Information System*).

Noncancer: A 5 month (subchronic) residential exposure for a child age 5 < 6 years. Exposure assumed to occur daily (indoor & outdoor) over that period. Exposure parameters are age-specific (see earlier discussion for the calculation of soil exposure rates). Subchronic Reference Dose = 0.0003 mg/kg/day from USEPA *Health Effects Assessment Summary Tables (HEAST)*. Target Hazard Index value = 1 based upon the magnitude (10) of Uncertainty Factors and Modifying Factors used to derive the Subchronic Reference Dose.

$$[OHM]_{soil} = (HI_{IH} \times RfD_{subchronic} \times C)/((ADSIR \times RAF_{oral}) + (ADSCR \times RAF_{dermal}))$$

$$[OHM]_{soil} = (1 \times 0.0003 \times 10^{6})/((5.3 \times 1) + (87.9 \times 0.2))$$

$$[OHM]_{soil,\ noncancer} = 13.1\ mg/kg$$

The Imminent Hazard Soil Trigger Level for Methyl Mercury is based upon the potential non-cancer risks: 13.1 mg/kg. No cancer risk-based concentration was calculated as methyl mercury is not considered to be carcinogenic. Expressed in one significant figure, 13.1 rounds to 10 mg/kg (ppm).

$$\textbf{Methyl Mercury}_{I.H.\ Trigger,\ Soil} = \textbf{10 mg/kg}$$

Polychlorinated Biphenyls (PCBs)

BASIS: Lowest Risk-Based Concentration:

Cancer: 30 year residential exposure, ages 0 to 30. Exposure parameters are age-specific and normalized to body weight. See <u>*Background Documentation for Numerical Standards (1/4/93)*</u>, Appendix A, for the calculation of soil exposure rates. Target risk level = one-in-ten thousand (10^{-4}). Carcinogenic Slope Factor = 7.7 per mg/kg/day from USEPA <u>*Integrated Risk Information System (IRIS)*</u>.

$$[OHM]_{soil} = (ELCR \times C)/(CSF \times ((RAF_{oral} \times NLADSIR) + (RAF_{dermal} \times NLADSCR)))$$

$$[OHM]_{soil} = (10^{-4} \times 10^{6})/(7.7 \times ((1 \times 0.41) + (0.067 \times 7.3)))$$

$$[OHM]_{soil,\ cancer} = 14.4 \text{ mg/kg}$$

Noncancer: A 5 month (subchronic) residential exposure for a child age 5 < 6 years. Exposure assumed to occur daily (indoor & outdoor) over that period. Exposure parameters are age-specific (see earlier discussion for the calculation of soil exposure rates). Subchronic Allowable Daily Intake = 0.00002 mg/kg/day from <u>*Chronic Oral Allowable Daily Intake For Aroclors*</u> (Memorandum to Carol Rowan West from Marion Harnois, ORS, 5/10/93). Target Hazard Index value = 10 based upon the number of Uncertainty Factors and Modifying Factors used to derive the Allowable Daily Intake.

$$[OHM]_{soil} = (HI_{IH} \times RfD_{subchronic} \times C)/((ADSIR \times RAF_{oral}) + (ADSCR \times RAF_{dermal}))$$

$$[OHM]_{soil} = (10 \times 0.00002 \times 10^{6})/((5.3 \times 1) + (87.9 \times 0.067))$$

$$[OHM]_{soil,\ noncancer} = 17.9 \text{ mg/kg}$$

The Imminent Hazard Soil Trigger Level for PCBs is based upon the potential cancer risks: 14.4 mg/kg < 17.9 mg/kg. Expressed in one significant figure, 14.4 rounds to 10 mg/kg (ppm).

$$PCBs_{I.H.\ Trigger,\ Soil} = 10 \text{ mg/kg}$$

APPENDIX E

REPORTABLE CONCENTRATIONS IN GROUNDWATER AND SOIL

APPENDIX E

REPORTABLE CONCENTRATIONS (RCs) IN GROUNDWATER AND SOIL

1.0 Introduction

The goal of this Appendix is to offer a brief explanation of the Reportable Concentrations (RCs) contained in the Massachusetts Contingency Plan (MCP; 310 CMR 40). The derivation and meaning of the RCs will be discussed, as will their application under the MCP.

2.0 Description

The Reportable Concentrations (RCs) are levels of an oil or hazardous material that, when found in soil or groundwater, trigger the reporting requirements explained in Subpart C of the Massachusetts Contingency Plan. Reportable Concentrations are extrapolated from one of two possible sources. For the 104 chemicals most frequently reported at sites in Massachusetts, the RCs have been extrapolated from the Method 1 Cleanup standards contained in Subpart I of the MCP. The remaining RCs listed in the Massachusetts Oil and Hazardous Material List (MOHML; 310 CMR 40.1600), are derived from Massachusetts Reportable Quantities (RQs) which are assigned to oil/hazardous material (OHM) by the MA DEP. [Note that these values are different from federal RQs assigned under CERCLA.] The Reportable Concentrations are a new and important part of the MCP and readers should refer to the regulations for their specific applicability.

When looking up the Reportable Concentrations in the MOHML one sees four RCs for each compound listed. The RCs are both media and exposure specific. Two of the RCs are applicable to groundwater: RCGW-1 and RCGW-2. (The acronym RCGW stands for Reportable Concentration in Ground Water.) The other pair of RCs is applicable to soil concentrations: RCS-1 and RCS-2 (RCS representing Reportable Concentrations in Soil). The RCGW-1 and RCS-1 numbers are applicable in situations where the potential for exposure to the soil or groundwater in question is high; conversely, RCGW-2 and RCS-2 numbers are applicable in situations where the potential for exposure is lower. All the Reportable concentrations are given in parts per million, the groundwater numbers are given as milligrams contaminant per liter of water (mg/l) and the soil numbers are stated as milligrams contaminant per kilogram of soil (mg/kg).

The use of the Reportable Concentrations listed in Table E-1 and in the MOHML (of which Table E-1 is a subset) is explained in detail in Subpart C (310 CMR 40.0300) of the MCP. The exceedance of an applicable RC (applicable in terms of media and exposure potential) triggers the 120-day notification requirement described in 310 CMR 40.0315, although there are circumstances under which 2-hour (310 CMR 40.0311) or 72-hour (310 CMR 40.0313) notification is required. These reporting requirements are complex and the Department encourages people to become familiar with the regulations in Subpart C before the need to notify arises.

3.0 Derivation

As previously stated, the Reportable Concentrations are developed from two different sources. For those chemicals found most frequently at Massachusetts sites, (i.e. the 104 chemicals listed in Table E-1) the RCs are extrapolated from the Method 1 Cleanup standards listed in Subpart I of the MCP, and which are explained in greater detail in the body of this document. As a result of being based on the Method 1 numbers, these RCs are closely correlated with levels of risk of harm to health, public welfare and the environment.

For these 104 chemicals the RCs in groundwater and soil are derived from the Method 1 Groundwater and Soil standards using the following strategy:

RCGW-1
Derived by choosing the **lowest** of the following Method 1 standards:

- **GW-1**
- **GW-2**
- **GW-3**

RCGW-2
Derived by choosing the **lowest** of the following Method 1 standards:

- **GW-2**
- **GW-3**

RCS-1
Derived by choosing the **lowest** of the following Method 1 standards:

- **S-1/GW-1**
- **S-1/GW-2**
- **S-1/GW-3**
- **S-2/GW-1**
- **S-3/GW-1**

RCS-2
Derived by choosing the **lowest** of the following Method 1 standards:

- **S-2/GW-2**
- **S-2/GW-3**
- **S-3/GW-2**
- **S-3/GW-3**

(Also see figure E-1 for a description of this process.)

It is important to note that while these Reportable Concentrations are extrapolated from the Method 1 Cleanup Standards, the two sets of numbers are **different** and their application and use are **distinct**, as explained in Subpart C and Subpart I of the MCP. The RCs are triggers for reporting and are meant to be applied early when a limited amount of information about the site is available. The Reportable Concentration is to be compared to the highest concentration found at a site; this means that only one value need to be above the RC to trigger the reporting requirement . In contrast, the Method 1 Cleanup Standards are used to determine the need for remediation and are used when the site has been better characterized and more information has been collected. The Method 1 Cleanup Standards are based on exposure point concentrations, which may be averages or weighted averages of a number of values (310 CMR 40.0973(3)). Therefore the need to remediate is not dependent on only one value exceeding a cleanup standard.

While it is true that the Reportable Concentrations and the Method 1 Cleanup Standards are distinct in meaning and application, it is often the case that if the RC has been exceeded that the applicable cleanup standard has been exceeded as well and remediation may be required. But it is important to note that being below an RC does not necessarily mean that a site poses no risk: it can only be concluded that no notification is required at this time. Notification and possibly remediation may be required if/when more is known about the site.

For the large number of chemicals listed on the MOHML which do not have Method 1 Standards a different strategy had to be applied to develop Reportable Concentrations. These RCs are based on the Reportable Quantities (RQs) assigned by the Massachusetts DEP to the compounds listed on the MOHML and are, therefore, general indicators of relative risk. Thus, for the majority of compounds listed on the MOHML the following method is used to extrapolate the listed RCs:

MA DEP RQ (lbs.)	RCGW-1*	RCGW-2*	RCS-1*	RCS-2*
1	0.1	1	10	100
5	0.5	5	50	500
10	1	10	100	1000
50	5	50	500	5000
100	10	100	1000	10000

*RCs are given in parts per million: mg/l for groundwater, mg/kg for soil

The application of all RCs is described in detail in Subpart C of the MCP.

4.0 Implications

Reportable Concentrations are ONLY triggers for reporting under the Massachusetts Contingency Plan and any other use of these numbers is not sanctioned by the Massachusetts Department of Environmental Protection.

Reportable Concentrations are NOT cleanup standards. The Method 1 Cleanup Standards are a distinct and separate list of numbers and their use is described in detail in Subpart I of the MCP.

Reportable Concentrations are NOT "No Risk" levels. Sites with reported concentrations of OHMs below RCs do not require notification to the Department but may pose a significant risk. Information gathered at a later date or through the DEP's Site Discovery Program may result in the need for notification and/or remediation at a site.

Reportable Concentrations are <u>NOT</u> screens to eliminate Contaminants of Concern form a Risk Assessment. The acceptable way to perform a Human Health and Ecological Risk Assessment is described in greater detail in the Guidance for Disposal Site Risk Characterization issued by the DEP's Office of Research and Standards and the Bureau of Waste Site Cleanup (revised draft expected in the Spring of 1994).

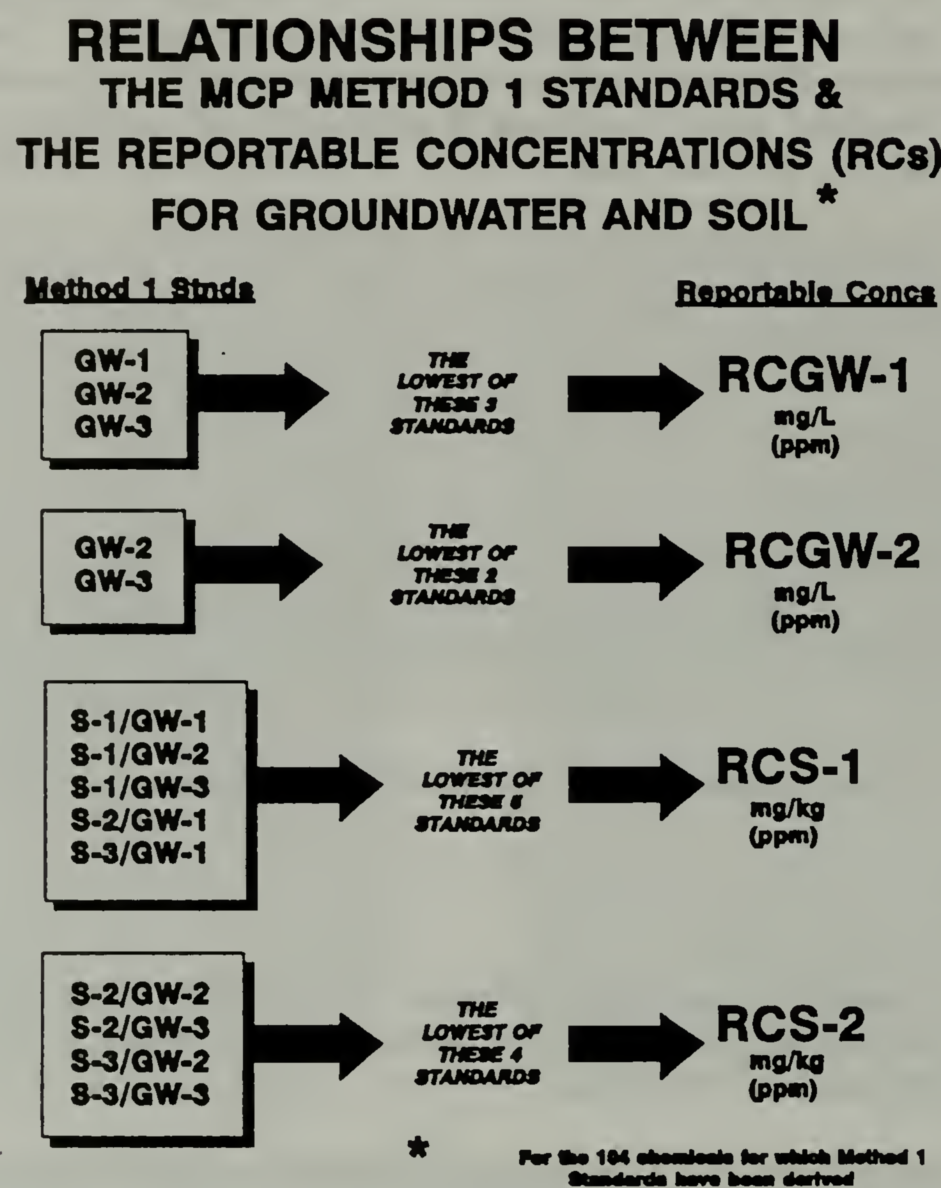


Figure E-1

Table E-1

REPORTABLE CONCENTRATIONS (RCs) IN GROUNDWATER AND SOIL

A Subset of Chemicals Extracted from 310 CMR 40.1600
The Massachusetts Oil and Hazardous Material List (MOHML)

See MCP Subpart C for the use of these RCs and the MOHML for additional chemicals.

OIL OR HAZARDOUS MATERIAL	RCGW-1 mg/L (ppm)	RCGW-2 mg/L (ppm)	RCS-1 mg/kg (ppm)	RCS-2 mg/kg (ppm)
ACENAPHTHENE	0.02	2	20	2000
ACENAPHTHYLENE	0.3	2	100	800
ACETONE	3	50	3	60
ALDRIN	0.0005	0.0005	0.03	0.04
ANTHRACENE	0.6	0.6	1000	1000
ANTIMONY	0.006	0.3	10	40
ARSENIC	0.05	0.4	30	30
BENZENE	0.005	2	10	60
BENZO(a)ANTHRACENE	0.0002	0.005	0.7	0.7
BENZO(a)PYRENE	0.0002	0.002	0.7	0.7
BENZO(b)FLUORANTHENE	0.0002	0.007	0.7	0.7
BENZO(g,h,i)PERYLENE	0.0001	0.0001	30	30
BENZO(k)FLUORANTHENE	0.0002	0.0004	0.7	0.7
BERYLLIUM	0.004	0.05	0.4	0.8
BIPHENYL, 1,1-	0.4	4	1	10
BIS(2-CHLOROETHYL)ETHER	0.03	0.1	0.7	0.7
BIS(2-CHLOROISOPROPYL)ETHER	0.03	0.4	0.7	3
BIS(2-ETHYLHEXYL)PHTHALATE	0.006	0.03	100	300
BROMODICHLOROMETHANE	0.005	50	0.1	20
BROMOFORM	0.005	0.8	0.1	20
BROMOMETHANE	0.002	0.002	3	3

REPORTABLE CONCENTRATIONS (RCs) IN GROUNDWATER AND SOIL

A Subset of Chemicals Extracted from 310 CMR 40.1600
The Massachusetts Oil and Hazardous Material List (MOHML)

See MCP Subpart C for the use of these RCs and the MOHML for additional chemicals.

OIL OR HAZARDOUS MATERIAL	RCGW-1 mg/L (ppm)	RCGW-2 mg/L (ppm)	RCS-1 mg/kg (ppm)	RCS-2 mg/kg (ppm)
CADMIUM	0.005	0.01	30	80
CARBON TETRACHLORIDE	0.005	0.02	1	4
CHLORDANE	0.002	0.002	1	2
CHLOROANILINE, p-	0.03	50	1	30
CHLOROBENZENE	0.1	0.5	8	40
CHLOROFORM	0.005	0.4	0.1	10
CHLOROPHENOL, 2-	0.01	40	0.7	20
CHROMIUM (TOTAL)	0.1	2	1000	2500
CHROMIUM (III)	0.1	2	1000	2500
CHROMIUM (VI)	0.05	0.1	200	600
CHRYSENE	0.0002	0.003	0.7	0.7
CYANIDE	0.01	0.01	100	100
DIBENZO(a,h)ANTHRACENE	0.0002	0.0003	0.7	0.7
DIBROMOCHLOROMETHANE	0.005	50	0.09	20
DICHLOROBENZENE, 1,2- (o-DCB)	0.6	8	100	500
DICHLOROBENZENE, 1,3- (m-DCB)	0.6	8	100	500
DICHLOROBENZENE, 1,4- (p-DCB)	0.005	8	2	60
DICHLOROBENZIDINE, 3,3'-	0.08	2	1	1
DICHLORODIPHENYL DICHLOROETHANE, P,P'- (DDD)	0.0001	0.006	2	3
DICHLORODIPHENYLDICHLOROETHYLENE,P,P'- (DDE)	0.0001	0.02	2	2
DICHLORODIPHENYLTRICHLOROETHANE, P,P'- (DDT)	0.0003	0.0003	2	2

REPORTABLE CONCENTRATIONS (RCs) IN GROUNDWATER AND SOIL

A Subset of Chemicals Extracted from 310 CMR 40.1600
The Massachusetts Oil and Hazardous Material List (MOHML)

See MCP Subpart C for the use of these RCs and the MOHML for additional chemicals.

OIL OR HAZARDOUS MATERIAL	RCGW-1 mg/L (ppm)	RCGW-2 mg/L (ppm)	RCS-1 mg/kg (ppm)	RCS-2 mg/kg (ppm)
DICHLOROETHANE, 1,1-	0.07	9	3	400
DICHLOROETHANE, 1,2-	0.005	0.02	0.05	0.2
DICHLOROETHYLENE, 1,1-	0.001	0.001	0.1	0.1
DICHLOROETHYLENE, CIS-1,2-	0.07	50	2	500
DICHLOROETHYLENE, TRANS-1,2-	0.1	50	4	1000
DICHLOROPHENOL, 2,4-	0.01	4	10	90
DICHLOROPROPANE, 1,2-	0.005	0.009	0.1	0.2
DICHLOROPROPENE, 1,3-	0.0005	0.005	0.01	0.1
DIELDRIN	0.0001	0.0001	0.03	0.04
DIETHYL PHTHALATE	0.03	0.03	0.7	0.7
DIMETHYL PHTHALATE	0.03	0.03	0.7	0.7
DIMETHYLPHENOL, 2,4-	0.1	20	0.7	10
DINITROPHENOL, 2,4-	0.2	2	3	6
DINITROTOLUENE, 2,4-	0.03	2	0.7	2
DIOXIN	3e-08	1e-07	4e-06	6e-06
ENDOSULFAN	0.0001	0.0001	0.05	0.05
ENDRIN	0.002	0.005	0.6	1
ETHYLBENZENE	0.7	4	80	500
ETHYLENE DIBROMIDE	0.00002	0.003	0.005	0.02
FLUORANTHENE	0.1	0.1	600	600
FLUORENE	0.3	1	400	1000

REPORTABLE CONCENTRATIONS (RCs) IN GROUNDWATER AND SOIL

A Subset of Chemicals Extracted from 310 CMR 40.1600
The Massachusetts Oil and Hazardous Material List (MOHML)

See MCP Subpart C for the use of these RCs and the MOHML for additional chemicals.

OIL OR HAZARDOUS MATERIAL	RCGW-1 mg/L (ppm)	RCGW-2 mg/L (ppm)	RCS-1 mg/kg (ppm)	RCS-2 mg/kg (ppm)
HEPTACHLOR	0.0004	0.001	0.1	0.2
HEPTACHLOR EPOXIDE	0.0002	0.002	0.06	0.09
HEXACHLOROBENZENE	0.001	0.04	0.7	0.8
HEXACHLOROBUTADIENE	0.0006	0.0006	3	3
HEXACHLOROCYCLOHEXANE, GAMMA (gamma-HCH)	0.0002	0.0008	0.1	0.5
HEXACHLOROETHANE	0.008	0.01	6	10
INDENO(1,2,3-cd)PYRENE	0.0002	0.0003	0.7	0.7
LEAD	0.02	0.03	300	600
MERCURY	0.001	0.001	10	60
METHOXYCHLOR	0.002	0.002	30	30
METHYL ETHYL KETONE	0.4	50	0.3	40
METHYL ISOBUTYL KETONE	0.4	50	0.5	70
METHYL MERCURY	0.0001	0.0001	7	20
METHYL TERT BUTYL ETHER	0.7	50	3	200
METHYLENE CHLORIDE	0.005	50	0.1	200
METHYLNAPHTHALENE, 2-	0.01	3	0.7	7
NAPHTHALENE	0.02	6	4	1000
NICKEL	0.08	0.08	300	700
PENTACHLOROPHENOL	0.001	0.08	5	10
PHENANTHRENE	0.05	0.05	100	100
PHENOL	4	30	60	500

REPORTABLE CONCENTRATIONS (RCs) IN GROUNDWATER AND SOIL

A <u>Subset</u> of Chemicals Extracted from 310 CMR 40.1600
The Massachusetts Oil and Hazardous Material List (MOHML)

See MCP Subpart C for the use of these RCs and the MOHML for additional chemicals.

OIL OR HAZARDOUS MATERIAL	RCGW-1 mg/L (ppm)	RCGW-2 mg/L (ppm)	RCS-1 mg/kg (ppm)	RCS-2 mg/kg (ppm)
POLYCHLORINATED BIPHENYLS	0.0003	0.0003	2	2
PYRENE	0.08	0.08	500	500
SELENIUM	0.05	0.08	300	2500
SILVER	0.007	0.007	100	200
STYRENE	0.1	0.9	2	20
TETRACHLOROETHANE, 1,1,1,2-	0.005	0.006	0.4	0.5
TETRACHLOROETHANE, 1,1,2,2-	0.002	0.02	0.02	0.2
TETRACHLOROETHYLENE	0.005	3	0.5	300
THALLIUM	0.002	0.4	8	30
TOLUENE	1	6	90	500
TOTAL PETROLEUM HYDROCARBONS	1	50	500	2500
TRICHLOROBENZENE, 1,2,4-	0.07	0.5	100	800
TRICHLOROETHANE, 1,1,1-	0.2	4	30	500
TRICHLOROETHANE, 1,1,2-	0.005	20	0.3	3
TRICHLOROETHYLENE	0.005	0.3	0.4	20
TRICHLOROPHENOL, 2,4,5-	0.1	0.1	2	2
TRICHLOROPHENOL 2,4,6-	0.01	10	3	60
VINYL CHLORIDE	0.002	0.002	0.3	0.3
XYLENES	6	6	500	500
ZINC	0.9	0.9	2500	2500

APPENDIX F

DEVELOPMENT OF

DILUTION/ATTENUATION FACTORS
(DAFs)

FOR THE LEACHING-BASED

SOIL STANDARDS

DEVELOPMENT OF DILUTION/ATTENUATION FACTORS (DAFs) FOR THE LEACHING-BASED SOIL STANDARDS

INTRODUCTION

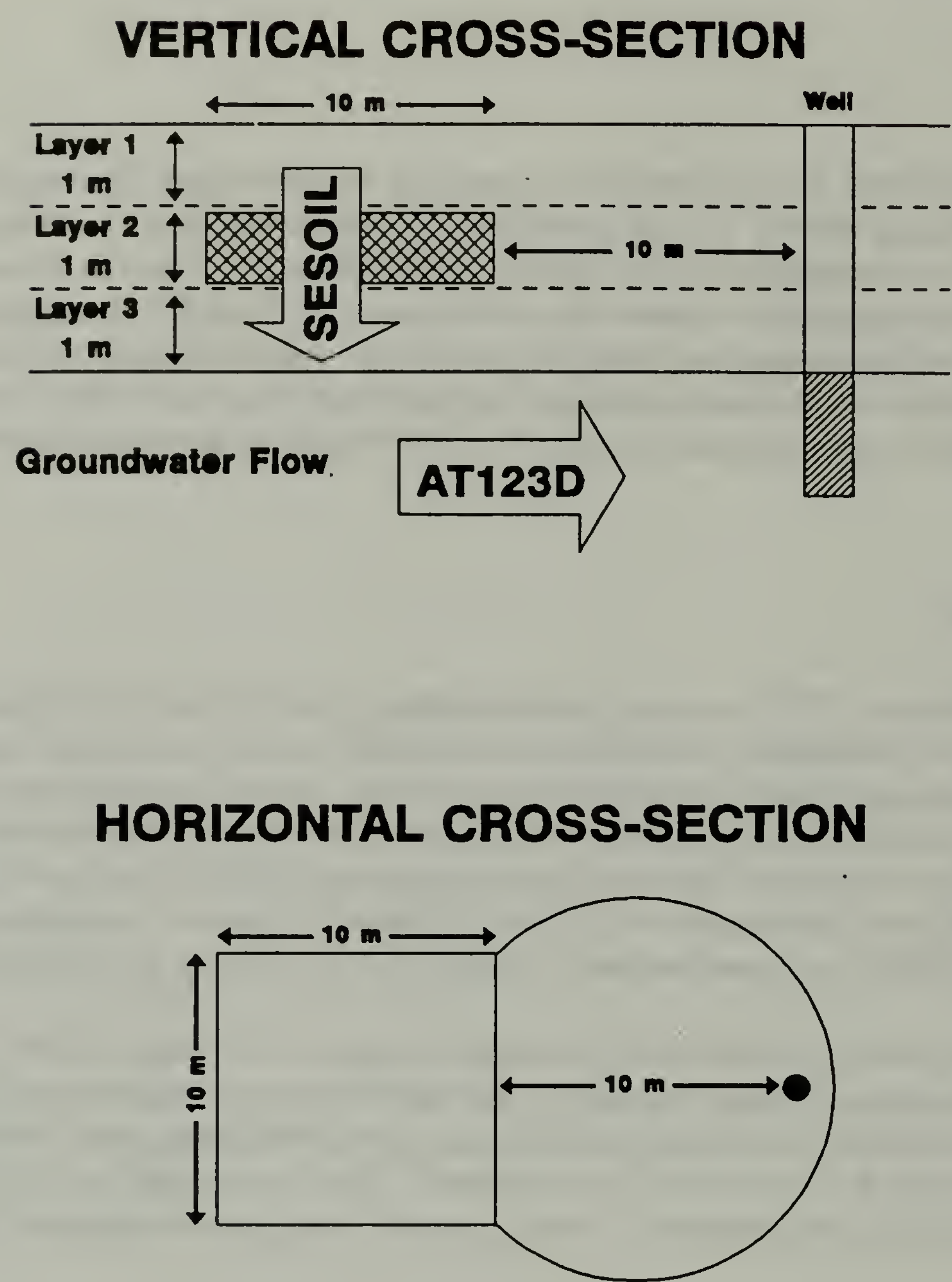
The Massachusetts Department of Environmental Protection has developed dilution attenuation factors (DAFs) in order to establish soil cleanup criteria for the protection of groundwater from leaching of residual contaminants in soil. DEP has adopted the modeling approach utilized by the State of Oregon in a similar process. This report describes the model and its application toward the development of DAFs for Massachusetts for a limited number of compounds of concern, and the subsequent development of one regression algorithm that relates DAFs developed by Oregon to those applicable in Massachusetts, and another algorithm that relates DAFs to chemical specific parameters. The pathway to groundwater is only one consideration in the final determination of an acceptable soil cleanup level.

THE OREGON MODEL

The Oregon model (Anderson, 1992) assumes a generic setting for a release of contaminant in the unsaturated zone and then applies the combination of SESOIL and AT123D models to estimate impact of the initial soil loading on a receptor assumed directly downgradient of the site via the groundwater pathway. The SESOIL and AT123D models, while previously individually developed (see References, Bonazountas, 1984 and Yeh, 1981), are a part of the risk assessment Graphical Exposure Modeling System (GEMS) developed by USEPA. A pc-based version of this (PCGEMS) was developed for USEPA by General Sciences Corporation (1989). The two models can now be linked so that SESOIL can pass leachate loadings to the saturated zone AT123D model.

The Oregon model's site setting (see Figure 1) assumes a 3-meter thick unsaturated zone, divided into three 1-meter layers. Contamination is initially released in the middle layer, as might occur for a leaking tank or for a residual contaminant remaining after some remedial excavation with clean cover backfill, and is uniformly distributed in this layer over a 10 meter by 10 meter area. The unsaturated zone and aquifer are assumed to be the same sandy soil with uniform properties. The upper and lower unsaturated zone layers are initially clean, as is the aquifer.

FIGURE 1
CONCEPTUAL SETTING



Source: Anderson (1991)

SESOIL inputs include the soil type parameters, chemical properties, application rates, and the climatic conditions of the area. The model is run as a transient monthly estimator of leachate volumes and concentrations. Initially, no other transport mechanisms other than leaching, partitioning, and volatilization were considered. Oregon used default values in SESOIL for Portland Oregon climatic conditions, but distributed total precipitation uniformly over the year.

SESOIL was initially found to overestimate losses via volatilization. A parameter, the volatilization fraction (VOLF), was introduced to allow adjustment of losses through this pathway and allow a site-specific calibration. This factor may be varied in time and space. The Oregon study used a uniform VOLF factor of 0.2, based on

consultation with a panel of experts. One other soil-related parameter is the disconnectedness index. This parameter varies for and within soil types. Two values are given as SESOIL defaults, and the larger, 7.5, has been used in the simulations. An increase in this parameter appears to result in a higher soil moisture, lower leachate rates, and somewhat lower DAFs (i.e., is more conservative) for the compounds run.

AT123D inputs include general aquifer properties, source configuration, loadings to groundwater, soil partition coefficients, and dispersivity values. The aquifer is assumed to be infinitely wide and thick. The pc-based version of AT123D accepts monthly transient loading rates calculated by SESOIL, and also provides a preprocessor for input file preparation and editing. In utilizing the model, the center of the 10 by 10 meter source area is assumed to be at coordinates 0,0,0. The positive x-axis is in the direction of flow. Calculated concentrations are maximum along the x-axis (y=0) and at the water table surface (z=0). Since the receptor is assumed to be 10 meters from the downgradient edge of the source area, the concentration at x=15, y=0, and z=0 represents the receptor location. Oregon used longitudinal, transverse, and vertical dispersivities of 20m, 2m, and 2m, respectively. These values seem high for a sandy aquifer, but the values have been retained to be consistent with the Oregon base values and to be protective of the Commonwealth's sensitive aquifers on Cape Cod. DAFs are proportional to the dispersivities, particularly sensitive to the vertical dispersivity.

Oregon ran the model for 10 indicator compounds and then developed a multiple linear regression model relating the DAF to the organic partition coefficient (K_{oc}) and the Henry's Law constant (H) to provide preliminary DAFs for sixty other organic compounds. Soil cleanup levels were generated based on the regression algorithm and a safe drinking water level for each compound. In some cases, risk based levels determined by other pathways were lower than the levels required to protect groundwater. In these instances, the lower value was selected as the soil target level. A similar approach was taken to develop the MCP Method 1 Standards, as described in Section 5.3.

SIMULATIONS FOR MASSACHUSETTS

The approach taken to develop DAFs for Massachusetts was to determine the effect that varying the location (changing the climatic conditions from Portland, Oregon to Boston, Massachusetts in SESOIL) would have on the Oregon calculated DAFs. If the model system was essentially linear with respect to loading, then DAFs already calculated for Oregon would be directly related to DAFs appropriate for Massachusetts, and the general algorithm developed by Oregon (with coefficients adjusted) could also be used to estimated DAFs for other compounds. To this end, model runs were made using the Oregon input values for SESOIL and AT123D with the exception of climate parameter values. Eight indicator compounds were selected: benzene, toluene, ethylbenzene, o-xylene, trichloroethene, tetrachloroethene, 1,1,1-trichloroethane, and naphthalene.

The input values for SESOIL are shown in Tables F-1 through F-4, and those for AT123D are shown on Table F-5. Depending on the mobility of the compound through the transport pathway, model runs varied from 2 years to 6 years as necessary to determine the maximum concentration attained at the receptor location for a specific compound. A point to consider in the adoption of the Oregon values, or adjustments to them, is the need to agree with the physio-chemical parameters that were used to generate the DAFs. Even in the eight indicator compounds selected, various accepted databases provide some widely varying values for S, H and K_{oc}. For example, for PCE, H is reported with an order of magnitude difference, and values of K_{oc} and solubility differing by a factor of 2 are reported for ethylbenzene in the literature.

Output concentrations at the selected receptor location demonstrated a cyclical nature due to seasonal variations in

precipitation and net recharge. Maximum concentrations were not always attained in the first cycle due to seasonal variability. However, the model output appeared to be linear with respect to the initial loading, allowing soil cleanup levels to be estimated based on the linear DAF approach. Table F-6 shows the model-based DAFs for Oregon and Massachusetts, and also, based on listed safe drinking water levels and the estimated DAFs for Massachusetts, what soil target levels would be for the eight indicator compounds run.

TABLE F-1
CLIMATE PARAMETER VALUES
FOR THE SESOIL MODEL

Default climate values for Boston as contained in the SESOIL model. Latitude = 42 degrees.

TABLE F-2
SOIL PARAMETER VALUES
FOR THE SESOIL MODEL

Intrinsic permeability	=	1×10^{-7} cm^2
Source area	=	1,000,000 cm^2
Porosity	=	0.3
Disconnectedness index	=	7.5
Soil bulk density	=	1.5 gm/cm^3
Soil organic carbon	=	0.1%
Layer 1 thickness	=	100 cm
Layer 2 thickness	=	100 cm
Layer 3 thickness	=	100 cm
No further sublayering specified		
Clay content	=	0%
All other parameters set to zero except those to indicate uniform parameters in all layers.		

TABLE F-3
APPLICATIONS DATA
FOR SESOIL MODEL

Application month	=	October only
layer	=	2
rate	=	1500 microgm/cm^2
year	=	1 only

Based on the area, thickness and bulk density, this produces an initial concentration of 10 ppm. No other sources are added.

Volatile fraction (VOLF)	=	0.2

Uniform in time and space.

All other parameter values set to zero.

TABLE F-4
CHEMICAL DATA FOR SESOIL MODEL

Compound	MW ml/g	K_{oc} mg/L	S atm-m^3/mol	H cm^2/sec	DA
benzene	78	83	1780	0.0055	0.109
ethylbenzene	106	575	161	0.00343	0.093
toluene	92	270	535	0.00668	0.100
o-xylene	106	302	171	0.00527	0.093
TCE	131	124	1100	0.00912	0.083
PCE	166	468	200	0.00204	0.075
1,1,1-TCA	133	157	730	0.0231	0.080
naphthalene	128	1288	31	0.00118	0.085

MW = molecular weight
K_{oc} = organic carbon partition coefficient
S = solubility in water
H = Henry's Law constant
DA = diffusion coefficient in air

TABLE F-5
AT123D MODEL INPUT PARAMETER VALUES

Soil bulk density	= 1.5 g/cc
Porosity	= 0.3
Hydraulic conductivity	= 0.5 m/hr
Hydraulic gradient	= 0.005
Longitudinal dispersivity	= 20.0 m
Transverse dispersivity	= 2.0 m
Vertical dispersivity	= 2.0 m

Loading (kg/hr) passed by SESOIL link program
Distribution coefficient = K_{oc} * fraction organic carbon
Source area = 10 m by 10 m, centered at 0,0
initial z penetration = 0

Degradation rates initially zero

TABLE F-6
MODEL OUTPUT DRAFT DAFS
COMPARISON AND SOIL LEVELS

Compound	Oregon DAF	Mass DAF	DRINKING WATER LEVEL mg/L	SOIL TARGET LEVEL ppm
benzene	44.4	56.5	0.005	0.28
ethylbenzene	103.5	121.1	0.700	84.8
toluene	64.5	80.6	1.000	80.6
o-xylene	65.4	83.3	10.000	833.3
TCE	65.4	76.3	0.005	0.38
PCE	73.0	86.2	0.005	0.43
1,1,1-TCA	133.2	169.2	0.200	33.8
naphthalene	207.0	222.2	0.280	62.2

STATISTICAL RELATIONSHIPS

A linear regression was run on the eight DAF data pairs with DAFs for Oregon as the independent variable. The model was :

$$DAF_{Mass} = A + B*DAF_{Oregon}$$

That is, the regression was not forced through the origin. For the eight data pairs, the equation was

$$DAF_{Mass} = 12.39 + 1.053*DAF_{Oregon}$$

with an r of 0.9913. Thus, over the range of data spanned by these eight compounds, the correlation appears good. Table F-7 shows a comparison of the DAFs calculated by the model and those by the linear regression equation above for the eight indicator compounds. Differences between the two methods are less than 10 percent.

A multiple linear regression algorithm for DAF(Mass) as a function of K_{oc} and H was also developed along the same lines as that developed by Oregon. This allows the calculation of DAFs for compounds for which Oregon did not consider, and which also may be used exclusively from the linear regression cited above. Two models were considered:

(a) $DAF = A + B*H + C*K_{oc}$, and
(b) $DAF = B*H + C*K_{oc}$.

where A, B, and C are regression coefficients. As with the Oregon analysis, it proved that the constant term was not statistically different from zero, and the simpler second model was adopted. Regression analysis yielded:

$$\boxed{DAF = 6207 * H + 0.166 * K_{oc}}$$

The fit here is somewhat better than the r-squared value of .956 for the Oregon model in that one compound with a large residual (carbon tetrachloride with a residual of 30) was not used here, and the average difference is much smaller with the eight compounds than for Oregon's ten. Table F-8 shows the relationship between the model DAFs and the regression expression predicted values. Only one compound varies more than 10 percent while six of the eight have percent differences less than five.

TABLE F-7
COMPARISON BETWEEN MODEL DAFS AND LINEAR REGRESSION DAFS BASED ON OREGON DAFS

Compound	Model DAF	Regr. DAF	% Difference
benzene	56.5	59.1	4.60
ethylbenzene	121.1	121.4	0.25
toluene	80.6	80.3	-0.37
o-xylene	83.3	81.3	-2.40
TCE	76.3	81.3	6.55
PCE	86.2	89.3	3.60
1,1,1-TCA	169.2	152.6	-9.81
naphthalene	222.2	230.4	3.69

TABLE F-8
RESULTS OF THE MULTIPLE LINEAR REGRESSION EQUATION FOR H AND KOC

Compound	Model DAF	Predicted	% Difference
benzene	56.5	47.9	-15.2
ethylbenzene	121.1	116.7	- 3.6
toluene	80.6	86.3	7.1
o-xylene	83.3	82.8	- 0.5
TCE	76.3	77.2	1.2
PCE	86.2	90.4	4.9
1,1,1-TCA	169.2	169.4	0.1
naphthalene	222.2	221.1	- 0.5

BIODEGRADATION

It is intuitive that biodegradation may play an important role in attenuating the potential impact of residual contaminants in soils on groundwater. However, there are a great many site-specific conditions that will determine actual biodegradation rates. Further, literature values cover a wide range and the exact conditions

under which they were estimated are rarely known. Literature values should be applied only with great caution to any estimation of contaminant fate and transport. In order to evaluate the potential effect of biodegradation, rate constants cited by Howard et al (1991) were input to the model for the five compounds of the eight indicator compounds known to degrade aerobically. This eliminated the chlorinated compounds TCE, PCE, and 1,1,1-TCA. In addition, one additional rate for benzene (0.002/day from the California LUFT guidance) was also run. Four runs were made for benzene as the most critical compound, at the California rate, at the high and low rates cited by Howard and at the geometric mean of the Howard high and low rates. Only one rate, the low Howard value, was used for each of the other four compounds. The reason for this will be seen shortly.

The degradation rates in Howard appear to be high, with half lives for the BTEX compounds on the order of days. This implies that within a year, residual concentrations in soil would be reduced by biodegradation several (three to six) orders of magnitude. Table F-9 presents the results of the model runs.

For all situations except for the two lowest rates for benzene, the DAFs become huge. In essence, this indicates that only trace amounts of the contaminants ever reach the groundwater table. Soil target level estimation using large DAFs and the linear approach should be done only with extreme caution. A contaminant in the subsurface will attempt to reach equilibrium concentrations in the air, moisture and sorbed to soil. At some total concentration, equilibrium solubility in moisture would be exceeded, indicating the probable presence of free product. In this case, the linearity and basic assumptions in the model may be violated. Of further consideration are the potential toxic effects on the biological population as concentrations of the compounds increase. For these circumstances, estimation of soil target levels considering biodegradation is very difficult.

TABLE F-9
RESULTS OF THE BIODEGRADATION RUNS

Compound	Rate in Soil 1/day	Rate in Water 1/day	DAF
benzene	0.002	0.001 *	84.7
benzene	0.0433	0.000963	2178.
benzene	0.0775	0.00817	1.5×10^4
benzene	0.1386	0.0693	5.7×10^7
toluene	0.0315	0.02475	8.7×10^6
ethylbenzene	0.0693	0.00304	1.8×10^{13}
o-xylene	0.02475	0.001899	2.8×10^5
naphthalene	0.01444	0.00269	8.6×10^{10}

* Note: Odencrantz's article on the California LUFT parameter values did not cite a rate for water. This was assumed here to be half that in soil. Note that not much more degradation occurs in the aquifer due to the rapid travel time to the receptor of about 11 to 12 days (large longitudinal dispersivity and low retardation).

SENSITIVITY

A detailed sensitivity analysis was not done at this point in time. However, Oregon did perform some sensitivity analyses, and sensitivity of these models as applied in California's LUFT program is discussed in another article (Odencrantz, et al, 1992)

REFERENCES

Anderson, M. 1992. Development of Generic Soil Cleanup Levels Based on Analysis of the Leachate Pathway. Environmental Cleanup Division, Department of Environmental Quality, State of Oregon, May 12, 1992.

Bonazountas, M. and J. Wagner. 1984. SESOIL. A Seasonal Soil Compartment Model. A.D. Little for USEPA.

General Sciences Corporation. 1989. PCGEMS User's Guide. Release 1.0. Prepared for U.S. Environmental Protection Agency Office of Pesticides and Toxic Substances Exposure Evaluation Division

Howard, P. et al. 1991. Handbook of Environmental Degradation Rates Lewis Publishers, Chelsea, Michigan.

Odencrantz, J., et al. 1992. Transport Model Parameter Sensitivity for Soil Cleanup Level Determinations Using SESOIL and AT123D in the Context of the California Leaking Underground Fuel Tank Field Manual. Journal of Soil Contamination 1(2):159-182.

Yeh, G. 1981. AT123D: Analytical Transient One-, Two-, and Three- Dimensional Simulation of Waste Transport in the Aquifer System. Oak Ridge National Laboratory. ORNL-5602.

APPENDIX G

SELECTION OF PRACTICAL QUANTITATION LIMITS FOR METHOD 1 CHEMICALS

APPENDIX G

Selection of Practical Quantitation Limits for Method 1 Chemicals

The majority of the Practical Quantitation Limits (PQL) for the MCP Method 1 chemicals are taken from one of three references on USEPA-approved laboratory methods. The references are as follows:

- USEPA Test Methods for Evaluating Solid Waste, SW-846, Third Edition (Revision 0), November 1986 (Reference 1)
- USEPA Methods for the Determination of Organic Compounds in Drinking Water, EPA-600/4-88/039, December 1988 (Revised July 1991) (Reference 2)
- Guide To Environmental Analytical Methods, Robert E. Wagner, Editor, Genium Publishing Corporation, 1992 (Reference 3)

The specific method on which the PQL is based is referenced in the two tables of PQLs in Section 3.1 (the explanation of the references follows Table 2-1). The references provide a method number. Below is a description of the various methods that appear in the references. From USEPA Test Methods for Evaluating Solid Waste (often referred to as SW-846), PQLs were excerpted from the following methods:

Method 8240: Volatile Organics by Gas Chromatography/Mass Spectrometry (GC/MS): Packed Column Technique

Method 8080: Organochlorine Pesticides and Polychlorinated Biphenyls by Gas Chromatography

Method 8270: Semivolatile Organic Compounds by Gas Chromatograhphy/Mass Spectrometry (GC/MS): Capillary Column Technique

Method 6010: Inductively Coupled Plasma Atomic Emission Spectroscopy

Method 7470: Mercury in Liquid Waste/Cold Vapor Technique

From the USEPA's Methods for the Determination of Organic Compounds in Drinking Water, PQLs were excerpted from the following methods:

Method 524.1: Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography/Mass Spectrometry

Method 524.2: Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry

Method 525.1: Determination of Organic Compounds in Drinking Water by Liquid-Solid Extraction and Capillary Column Gas Chromatography/Mass Spectrometry

From the Guide to Environmental Analytical Methods, a reference that condenses information in SW-846, EPA 200, 500, and 600 Series; Standard Methods; and the Contract Laboratory Program (CRP) into one book, PQLs were excerpted from the following methods:

Method 335: Determination of Total and Amenable Cyanide

Method 200.7: Atomic Absorption Methods

Method 508: Drinking Water Method for Pesticides: GC/ECD

Method 625: Priority Pollutants in Wastewater: Base/Neutrals, Acids, and Pesticides: GC/GC/MS

Method-Specific Adjustments

For certain methods, the PQL was not listed and had to be calculated from a Method Detection Limit (MDL). For the analysis of compounds in drinking water, sometimes a range of PQLs was provided because the method allowed for variations in laboratory methodologies or equipment. The specific assumptions that were made in selecting the PQL that appears in the Section 3.1 tables are discussed below under the various laboratory methods.

Methods 8270 and 8240:

The PQLs in the Section 3.1 tables are as listed in SW-846. No adjustments were necessary.

Method 8080:

The PQLs in the Section 3.1 tables were calculated from the Method Detection Limits provided in Table 1 of Method 8080 in (Reference 1). A formula is given in Method 8080 to calculate PQLs from MDLs. It is as follows:

PQL = MDL (Table 1) x Factor (Table 2)

For soil PQLs (in ug/kg), the factor in Table 2 that was used as a multiplier is 670, for low-level soil by sonication with GPC cleanup. For water PQLs, a factor of 10 was used as a multiplier.

Method 6010:

For compounds analyzed for using Method 6010, estimated instrumental detection limits are given in units of ug/l in Table 1 of Reference 1. Estimated instrumental detection limits are equivalent to PQLs. For water PQLs, the PQL was simply extracted from Table 1. For soil PQLs, a water-to-soil conversion factor was applied to the estimated detection limit to arrive at a PQL in units of mg/kg. The conversion factor was equal to 0.2; in other words, the estimated detection limit in ug/l was multiplied by 0.2 to arrive at a PQL in mg/kg. The conversion factor accounts for soil sample preparation procedures (in which one gram of soil is digested in 200 mL of water) and a units conversion (from ug/l to mg/kg).

Methods 524.1, 524.2 and 525.1 are used to analyze for compounds in drinking water; they are part of EPA's 500 series for organic compounds in drinking water.

Method 524.1:

For compounds analyzed for using Method 524.1, MDLs are reported in Table 3 of Method 524.1 (in Reference 2). The PQL was assumed to be equal to five times the MDL, an assumption supported in Standard Methods for the Examination of Water and Wastewater, 17th edition, 1989.

Method 524.2:

Analyzing for purgeable organics using this method can be done using two different laboratory setups: the first is a wide bore capillary column (Table 4 in Method 524.2) and the second is a cryogenic trapping option and a narrow bore capillary column (Table 5 in Method 524.2). Both tables appear in Reference 2. Because laboratories analyzing samples from 21E sites could use either technique, PQLs were calculated for both techniques and the higher of the two PQLs was selected for the development of the Method 1 standards. The higher of the two PQLs was chosen because either technique is acceptable and choosing the higher allows for both techniques to be used. (Both Table 4 and 5 report MDLs; so PQLs were calculated as five times the MDL.)

Method 525.1:

MDLs are provided in Method 525.1 Tables 4 and 6 in Reference 2. As with Method 524.2, two laboratory techniques are allowable under Method 525.1, one involves an ion trap mass spectrometer and the other involves a magnetic sector mass spectrometer. Both sets of PQLs were calculated (as five times the MDL) and the higher of the two PQLs for a given chemical was selected as the representative PQL for that method.

Method 335:

An MDL for cyanide is provided in EPA Method 335 in Reference 3. A PQL was estimated as five times the MDL.

Method 200.7:

Estimated instrumental detection limits are provided in Table 1 for Method 200.7 (in Reference 3). These are equivalent to PQLs.

Method 508:

Estimated detection limits (EDLs) are reported in Table 2 for Method 508. These are defined in a footnote to the table as being equivalent to MDLs. Therefore, PQLs were estimated as five times the EDLs.

Comments on PQLs for Specific Chemicals

For a few chemicals, certain assumptions were made in the calculation or identification of a PQL. These are listed below:

- Because o-xylene and p-xylene co-elute in Method 524.1, the PQL for xylenes in water is the sum of the individual PQLs for these two compounds.

- The PQL for trans-1,2-dichloroethylene was assumed to be the PQL for 1,2-dichloroethylene (mixed).

Commonwealth of Massachusetts

Executive Office of Environmental Affairs

Department of Environmental Protection

Bureau of Waste Site Cleanup

and

Office of Research & Standards